ERDC/TEC TR-01-3

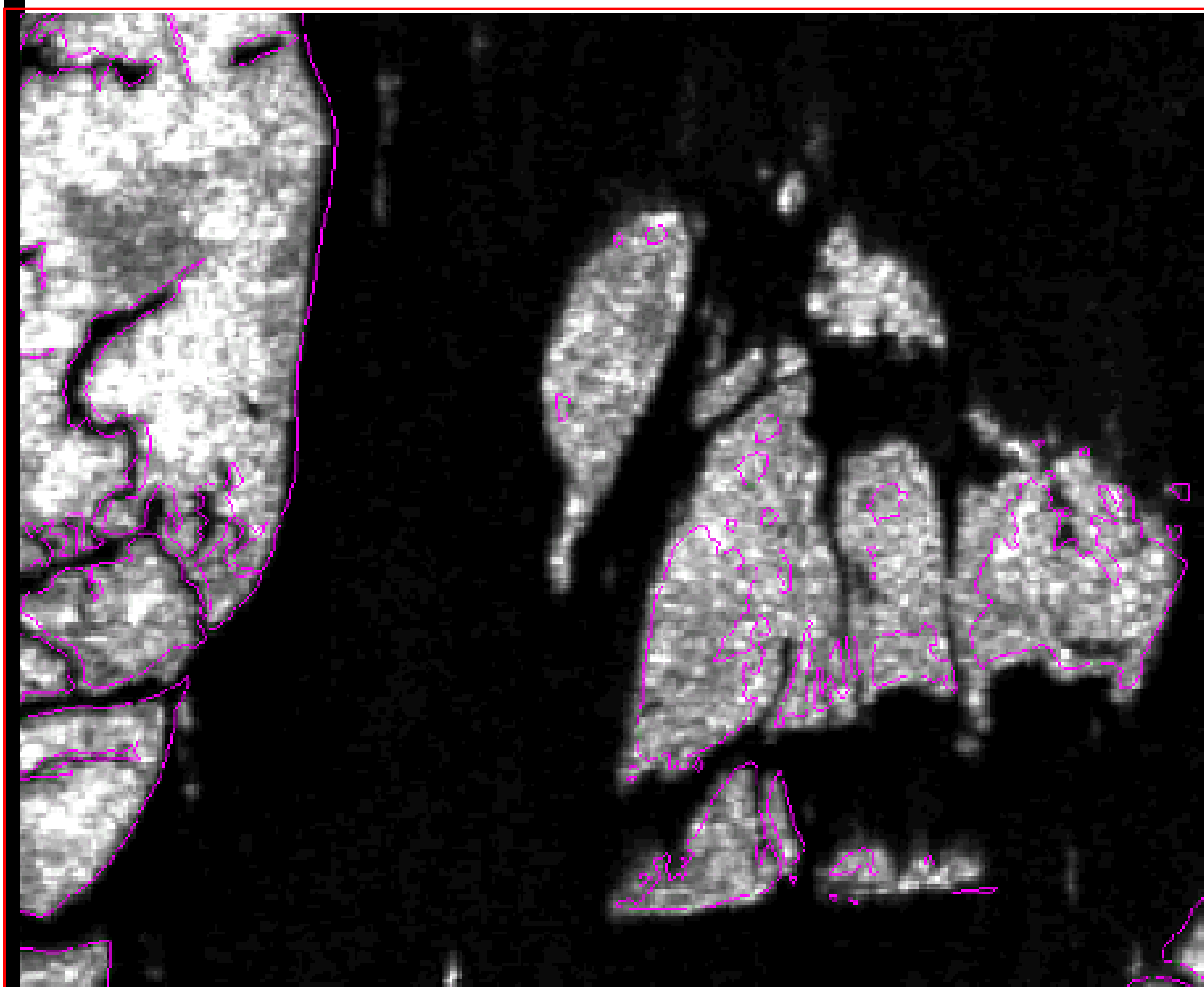
Topographic Engineering Center

US Army Corps of Engineers®
Engineer Research and Development Center

Comparing Digital Flood Insurance Rate Maps (DFIRMs) to Interferometric Synthetic Aperture Radar (IFSAR) Products

September 2000

James J. Damron



REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
September 2000

3. REPORT TYPE AND DATES COVERED
Technical Note December 1999 - July 2000

4. TITLE AND SUBTITLE
Comparing Digital Flood Insurance Rate Maps (DFIRMs) to Interferometric Synthetic Aperture Radar (IFSAR) Products

5. FUNDING NUMBERS

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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Topographic Engineering Center
7701 Telegraph Road
Alexandria, VA 22315-3864

8. PERFORMING ORGANIZATION REPORT NUMBER
ERDC/TEC TR-01-1

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
As part of the Federal Emergency Management Agency (FEMA) Map Modernization program, Flood Insurance Rate Maps (FIRMs) are converted from hard copy products to Digital Flood Insurance Rate Maps (DFIRMs). The next generation of DFIRMs will have more data and better accuracy than the hard copy FIRMs. FEMA's main goal is to have the ability to update DFIRMs using Geographic Information System (GIS) as humans change their physical and manmade environments. This means flood models will accurately reflect the natural and manmade environments. This study investigates the accuracy of several layers of the DFIRMs for the Virginia Beach, VA, area using Interferometric Synthetic Aperture Radar (IFSAR) products. IFSAR Digital Elevation Model (DEM) and Ortho-Rectified Image (ORI), referred to as a magnitude image, were used to compare the data accuracy and content of the DFIRMs. This study will provide timely information needed for future DFIRM production.

14. SUBJECT TERMS
DFIRMs, IFSAR, ArcInfo, DEM, ORI, DLG, Arc Interchange File, NAD27, NAD83, NAVD27, NAVD88, NASA, FEMA, DGPS, INS

15. NUMBER OF PAGES
124

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	

PREFACE

This study was sponsored by the Federal Emergency Management Agency (FEMA) and managed by the U.S. Army Engineer Research and Development Center's (ERDC) Topographic Engineering Center (TEC).

The study was conducted during the period December 1999 to July 2000. Mr. Anthony R. Niles was Chief, Geospatial Engineering Branch, and Mr. William Z. Clark was Director, Topographic Research Division, during this period.

Colonel James A. Walter was the Director of ERDC's TEC at the time of publication of this report.

ACKNOWLEDGMENTS

Appreciation is hereby given to the following TEC employees: Dr. Alta Walker, Terrain Analysis Branch; Jamie Richardson, Products & Services Branch; and John Nedza, Terrain Data Generation Branch, who assisted in the review of the applied methodologies used within the study.

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INTRODUCTION

The evolution of digital data has opened the door for exploration and for unlimited possibilities for the future. The Federal Emergency Management Agency (FEMA) is in a digital revolution. FEMA will convert Flood Insurance Rate Maps (FIRMs) to Digital Flood Insurance Rate Maps (DFIRMs) under the Map Modernization Flood Hazard Mapping Program. The first phase will convert hardcopy FIRMs to DFIRMs. Future FIRM studies will be based upon softcopy mapping technologies. The main goal of FEMA is to be able to update DFIRMs using Geographic Information System (GIS). Information on the current program is provided at http://www.fema.gov/mit/tsd/MM_DFHM.htm.

Background

The evolution of digital mapping technologies in the field of Digital Elevation Model (DEM) production with the advent of digital photogrammetry parallels the development of the Interferometric Synthetic Aperture Radar (IFSAR) collection systems. The IFSAR collection system uses dual Synthetic Aperture Radar (SAR) to actively illuminate the ground at a slant angle on a fixed wing aircraft in forward flight.

The aircraft's Differential Global Positioning System (DGPS) and Inertial Navigation System (INS) devices also collect information used for post processing the radar data on the ground. General information on GPS is located at the Global Positioning System Data & Information web site http://192.5.41.239/gps_datafiles.html maintained by the United States Naval Observatory. INS devices collect information on the aircraft's three axes — pitch, yaw, and roll — as well as the aircraft's airspeed and heading while in forward flight. Without these devices, data collected from IFSAR systems could not be geo-referenced to a location on the earth. The elevation of the ground is derived by processing the reflective radar data using the DGPS and INS information from the aircraft and IFSAR collection system.

Currently, there is only one commercial IFSAR collection device and it is owned and operated by Intermap Technologies Inc. Information on Intermap's IFSAR collection capabilities and products can be found at the following Web site: http://www.intermaptechnologies.com. Intermap Technologies Inc. will be further referred to as Intermap. This study will focus on the comparison of IFSAR products to DFIRMs, in terms of data accuracy and content.

The IFSAR data were collected over the Virginia Beach, Virginia, area as part of NASA's Commercial Remote Sensing Program involving the Scientific Data Purchase Program at the Stennis Space Center, Mississippi. The Topographic Engineering Center (TEC) requested IFSAR products from the Scientific Data Purchase Program. DFIRMs were requested from Dewberry & Davis through its Fairfax, Virginia, office.

Purpose

There were two main objectives for this study. First, to see how IFSAR-derived products can be used to enhance DFIRMs. Second, to determine which vector categories in the DFIRMs could best benefit from IFSAR-derived products. The comparative analysis was accomplished by using GIS software ArcInfo 8.0.1 on a UNIX workstation and Quattro Pro 9. Data formats were evaluated to provide information about these products. Understanding the different data formats of the IFSAR and DFIRM products is sometimes difficult and describing the two different products was an important component in understanding the data. Information on IFSAR and DFIRM products are placed throughout the study for further reading as Web or document references.

Scope of Study

The short-term benefit to FEMA will be information on the current state of horizontal accuracy of DFIRMs used during the early production years prior to the DFIRM 2.0 and 2.1 specifications. The long-term benefit to FEMA is to provide a better understanding of IFSAR product accuracies and how these products might help to update and improve DFIRMs when other products are not available for the task. This study was conducted from December 1999 to February 2000 with a three-month break while waiting for a new DFIRM data set, and from May 2000 to July 2000.

IFSAR DATA

The IFSAR DEM and Ortho-Rectified Image (ORI) products covered an approximate area of 691 mi^2 or 1789 km^2. The IFSAR collection, shown in Figure 1 on the next page, is within the southeast corner of Virginia. The IFSAR collection encompassed all or portions of six counties: Chesapeake, Newport News, Norfolk, Portsmouth, Suffolk, and Virginia Beach. The IFSAR DEMs and ORIs were delivered in a UTM projection, Zone 18, WGS84 horizontal datum, and units in meters.

The IFSAR DEM was converted from the WGS84 ellipsoid heights to orthometric heights (mean sea level) using a worldwide geoid model similar to the NGS GEOID96 model prior to the delivery, which Intermap refers to as the EGM96 vertical datum. Information on the global geopotential model EGM96 used by Intermap to obtain orthometric heights for DEMs can be found at http://cddisa.gsfc.nasa.gov/926/egm96/egm96.html (NASA). Intermap used the GEOID96 model as part of this delivery. The accepted geoid model used in the United States is the GEOID99 model, which replaces the older GEOID96 model (NGS). The geoid model is added to the ellipsoid heights, thereby producing the normal curvature of the earth. This normal curvature is important because it provides the correct elevation of the earth's surface for water to flow downhill and for line-of-sight investigations involved within the telecommunication industry.

Data Formats

The IFSAR DEM data included 15 DEM files with associated header files in a .txt extension. The format of the IFSAR DEM data was an IEEE floating point, 32-bit signed binary file format with a .bil extension and a 5-m post space. The IFSAR DEM delivered was the Global Terrain one (GT1) product with a horizontal accuracy of 2.5-m Root-mean-square Error (RMSE) and a vertical accuracy of 1-m RMSE. Information on the IFSAR DEM product line can be found at http://www.globalterrain.com/products.html. The sample header file, seen in Appendix A, was used to write new header files and allowed the IFSAR DEM data to be imported into ArcInfo. A sample header file with a .hdr extension is shown in Figure 2. The .bil extension of the IFSAR DEMs was changed to a .dem so the data could be imported into ArcInfo using the ifsargrid.aml seen in Appendix B. The IFSAR DEM data were imported into ArcInfo using the *FLOATGRID* command. The IFSAR DEM file names are shown in Table 1. The *PROJECTDEFINE* command was used to add coordinate system information to each DEM file.

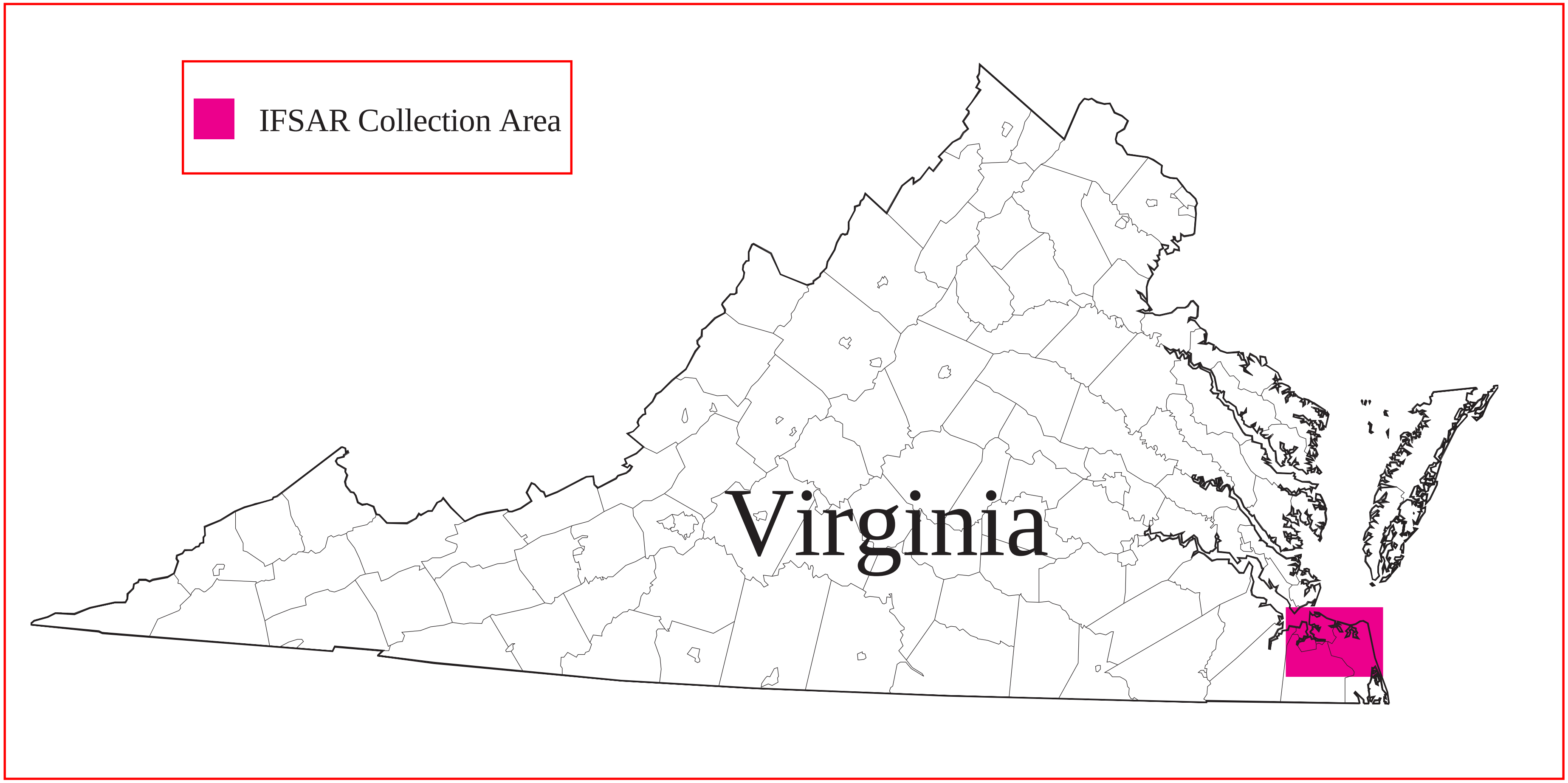


Figure 1. IFSAR Collection Area

```
nrows 2901
ncols 1807
xll 410167.5
yll 4067232.5
cellsize 5
NODATA_value  -9999
byteorder     MSBFIRST
```

Figure 2. Sample New Header file

Table 1. IFSAR DEMs

gt1n36w075f8v1	gt1n36w076f3v1	gt1n36w076g4v1
gt1n36w075g8v1	gt1n36w076f4v1	gt1n36w076h1v1
gt1n36w075h8v1	gt1n36w076g1v1	gt1n36w076h2v1
gt1n36w076f1v1	gt1n36w076g2v1	gt1n36w076h3v1
gt1n36w076f2v1	gt1n36w076g3v1	gt1n36w076h4v1

The IFSAR ORI products, referred to as a magnitude image, were collected and delivered with west and south orientation, referred to as a look. The west and south look ORIs consisted of 15 GEOTIFF, 8-bit format images with embedded coordinates to reference each image with a 2.5-m pixel size and a horizontal accuracy of 2.5-m RMSE. All ORI files were accompanied by an ASCII metadata file with a .txt extension. Information on the ORI products can be found at http://www.globalterrain.com/products.html. One example of these files is shown in Appendix C. The ORI data were imported into ArcInfo using the *IMAGEGRID* command with a sample ORI seen in Figure 3. The ORI south and west look file names are shown in Table 2. Finally, the *PROJECTDEFINE* command was used to add coordinate system information to each file.

Figure 3. Sample ORI

Table 2. ORIs

im2n36w075f8v1	im2n36w076f3v1	im2n36w076g4v1
im2n36w075g8v1	im2n36w076f4v1	im2n36w076h1v1
im2n36w075h8v1	im2n36w076g1v1	im2n36w076h2v1
im2n36w076f1v1	im2n36w076g2v1	im2n36w076h3v1
im2n36w076f2v1	im2n36w076g3v1	im2n36w076h4v1

IFSAR Anomalies

The IFSAR DEMs had one noticeable anomaly in the delivered data set. This anomaly was discovered when a hill shading technique was applied to the merged IFSAR DEMs. One DEM sheet, gt1n36w076h3v1, had a visible line along three adjoining sheets (Figure 4). Further investigation using the *CELLVALUE* command at the GRID prompt showed the sheet to be 0.24 m lower than three adjoining sheets. Intermap concurred with the findings and agreed to correct the problem. A new DEM data set was delivered. The IFSAR DEMs were merged and checked for the same problem. No problems were found in the new delivery of the IFSAR DEMs.

Dropouts, normal occurrences with IFSAR collections, are visible in the ORIs as black areas with no data. Most are created from shadowing effects of the physical terrain or large objects. In Figure 5, data dropouts are visible as black areas in the clipped image from the west look data set. It was not clear why the dropouts occurred in these areas. Data distortions are another type of anomaly associated with collections. In Figure 6, the distorted data near the water body are caused by the reflection of roofs of nearby buildings in that area. The distortion in Figure 7 is caused by the combined reflection of several roofs.

This collection was different from prior IFSAR collections due to the delivery of a west and south look. Intermap explained to TEC that the west look is the primary data set and the south look is the secondary data set. Both data sets were accidentally merged together and displayed a minor anomaly that appeared interesting and could warrant further investigation at a later time. In Figure 8, a clipped image of the merged west and south looks shows a visible offset of several meters. It is unknown at this time what the cause could be. The offset was reported to Intermap and its technical support recommended that the west and south looks not be merged.

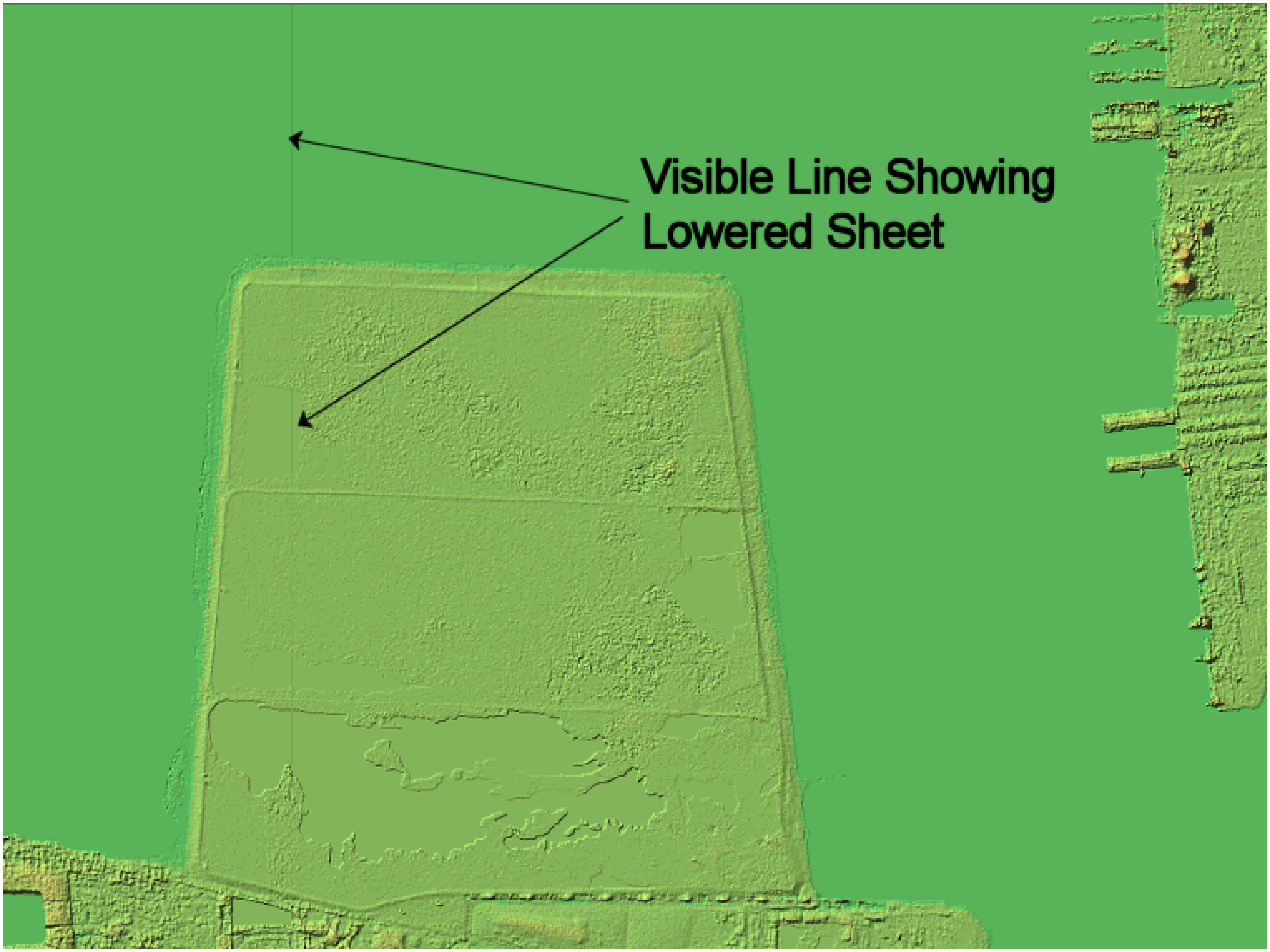


Figure 4. Visible Line Indicating Lower DEM

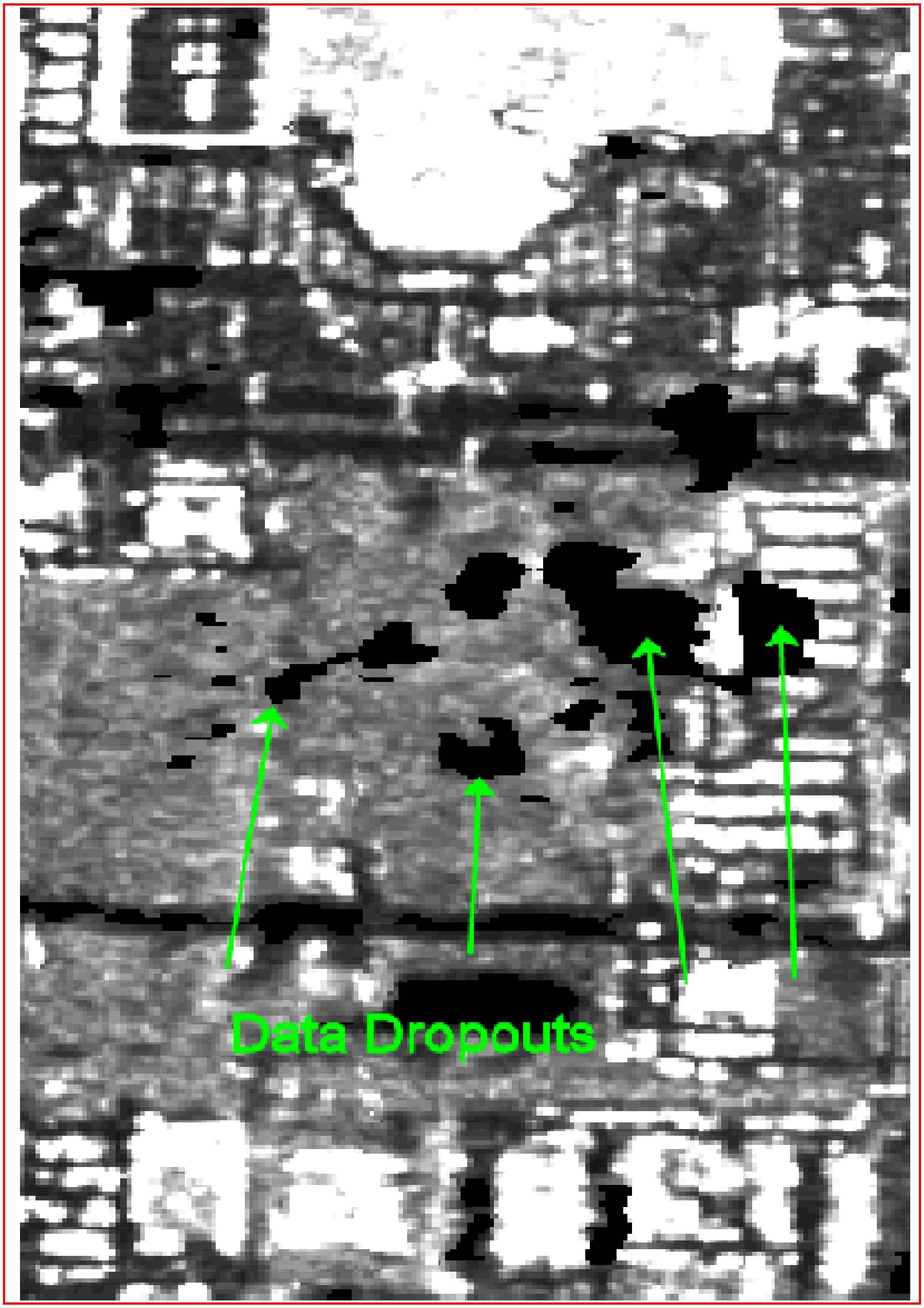


Figure 5. Black Areas Indicate Data Dropouts

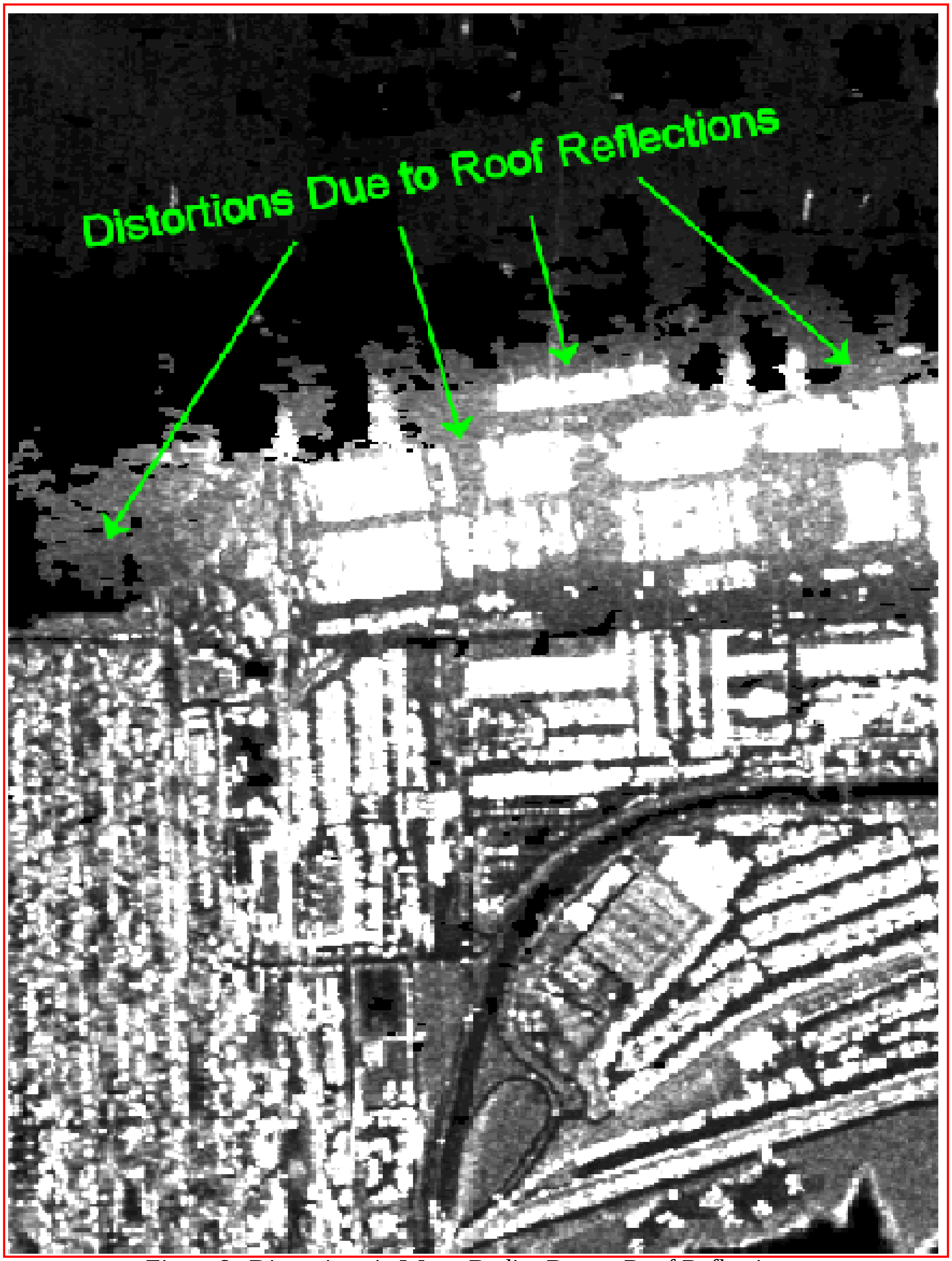


Figure 6. Distortions in Water Bodies Due to Roof Reflections

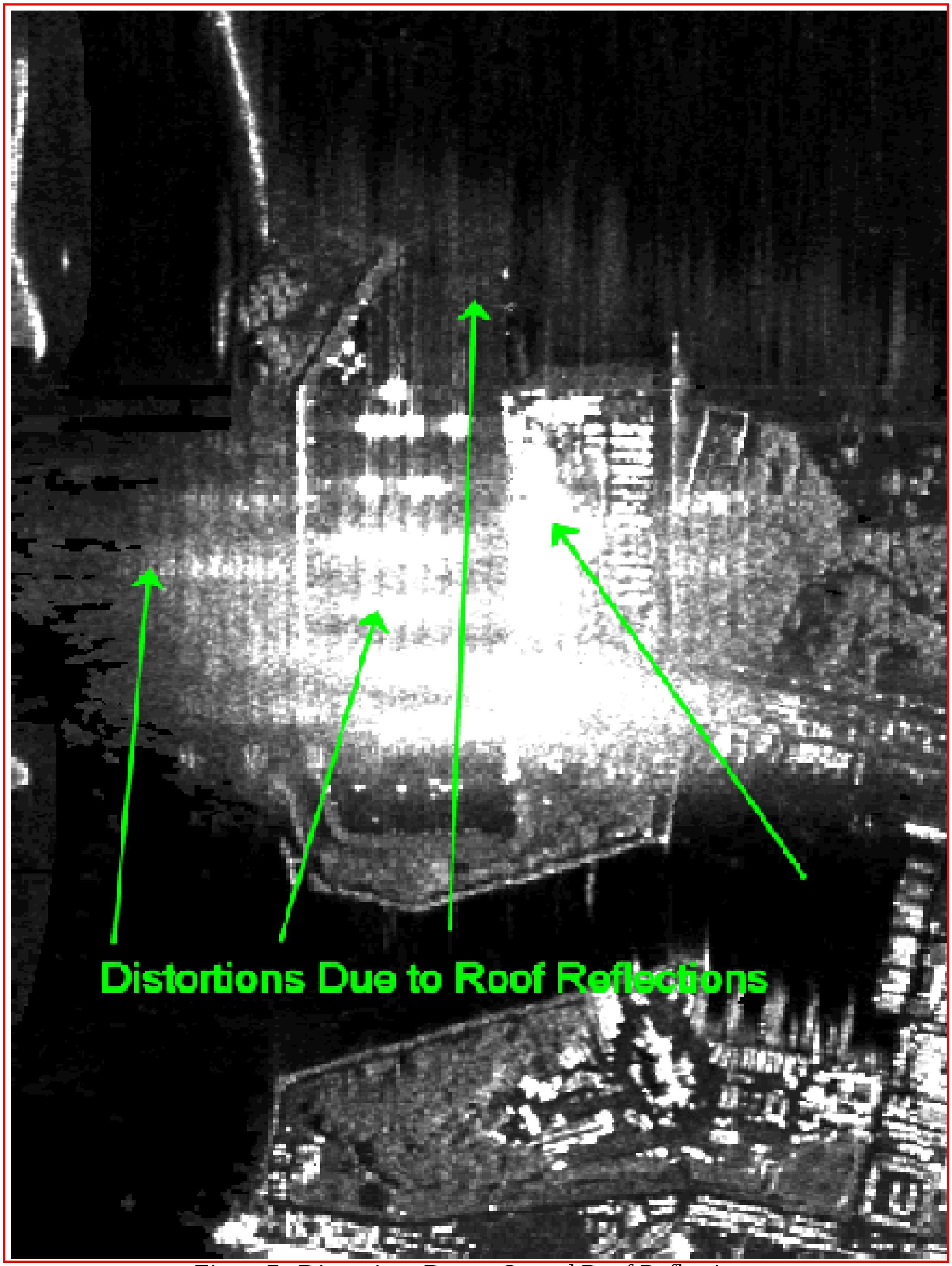


Figure 7. Distortions Due to Several Roof Reflections

Figure 8. Offset from Merging West and South Looks

DFIRM DATA

DFIRM sheets are designed around the bounding box of a standard USGS 7.5-minute 1:24,000-scale map sheet, referred to as a quad. The DFIRM data set delivered to TEC was in a UTM projection, zone 18, North American Datum of 1927 (NAD 27), National Geodetic Vertical Datum of 1929 (NGVD 29), and units in meters. The DFIRMs covered all of Virginia Beach County and encompassed more than half of the IFSAR collection area shown in Figure 9. DFIRMs are based on the USGS Digital Line Graphs three (DLG-3) format, which provides a full range of attribute codes and are fully topologically structured (USGS).

Data Format

The first DFIRM data set was delivered by Dewberry & Davis in a DLG format with a .dlg extension. The DLGs were delivered on CD-ROM in four categories: flood hazard zones (f), hydrography (h), map panel (m), and political areas (p). They include 12 sheets per category, shown in Table 3. The file naming convention for the DFIRMs is that the first five characters indicate the state/county fips code, the sixth character is the file category, and the last two characters are the sheet identifiers. Four ARC Macro Language (AML) scripts were written to import the DLGs into ArcInfo seen in Appendixes D, E, F, and G, which assigned character attributes to the numerical values of the DLGs for easy interpretation.

Table 3. DLGs

Flood Hazard	Hydrography	Map Panel	Political Areas
51810faa	51810haa	51810maa	51810paa
51810fab	51810hab	51810mab	51810pab
51810fac	51810hac	51810mac	51810pac
51810fba	51810hba	51810mba	51810pba
51810fbb	51810hbb	51810mbb	51810pbb
51810fbc	51810hbc	51810mbc	51810pbc
51810fca	51810hca	51810mca	51810pca
51810fcb	51810hcb	51810mcb	51810pcb
51810fcc	51810hcc	51810mcc	51810pcc
51810fdb	51810hdb	51810mdb	51810pdb
51810fdc	51810hdc	51810mdc	51810pdc
51810fdd	51810hdd	51810mdd	51810pdd

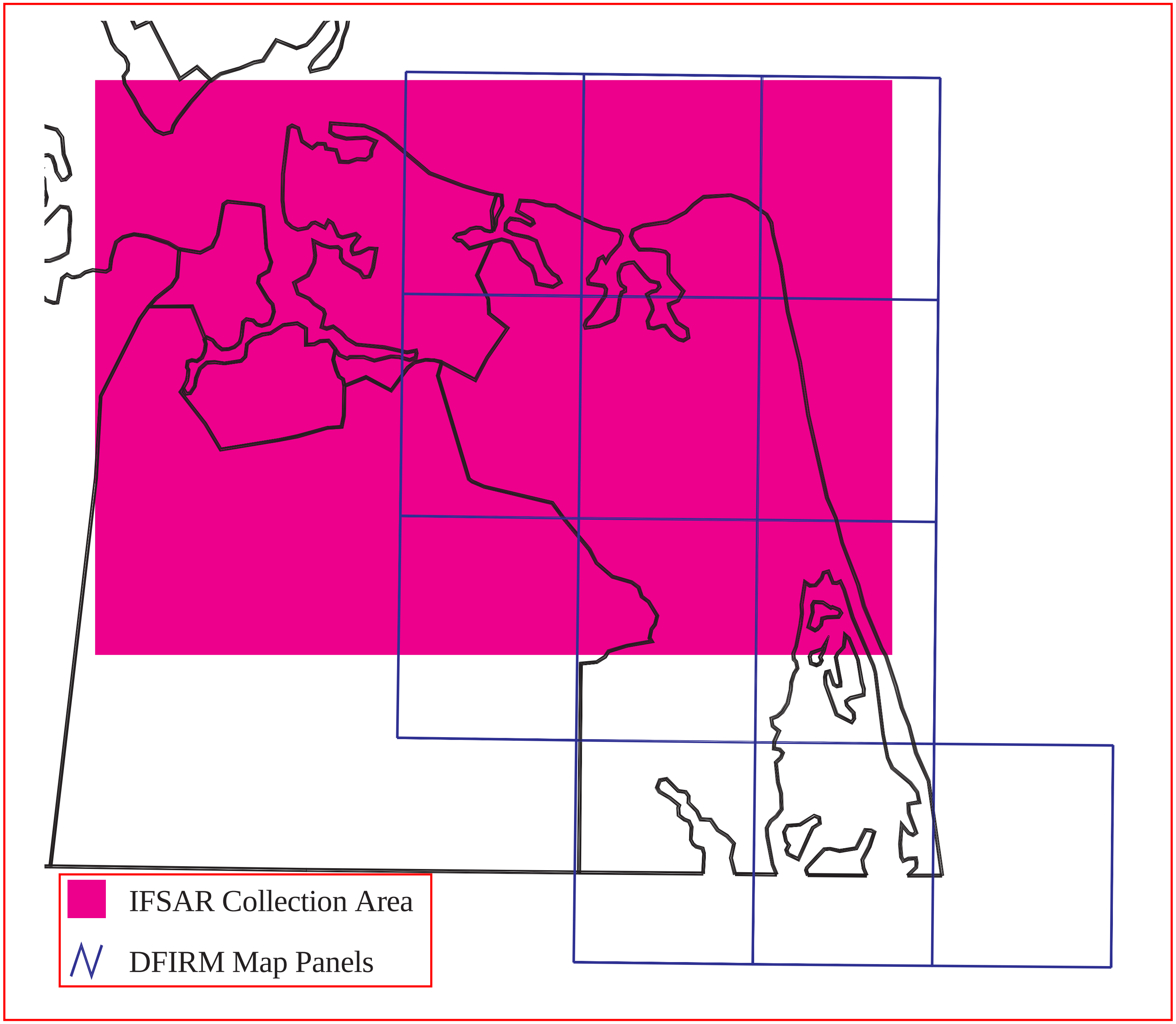


Figure 9. IFSAR Collection Area Overlaid with DFIRM Map Panels

DFIRM Anomalies

Figure 10 is an example of one of the many errors found in the DLG DFIRMs. Adjoining quad vertices were offset by as much as 1 m, and some quads overlapped each other. The DLG DFIRMs were an intermediate version that required many hours of *EDGEMATCHING* in ArcEdit to correct problems found in the DFIRM vectors. TEC asked Dewberry & Davis to deliver a finalized seamless version of the Virginia Beach DFIRMs when available.

Second DFIRM Data Set

The second DFIRM data set was delivered to TEC on May 8, 2000. The Arc Interchange format with a .e00 extension was the chosen format for the second delivery. The Arc Interchange format had the same attribution scheme as the previous DLG format. The DFIRMs were delivered on CD-ROM with five different categories: elevation reference marks (e), flood (f), hydrography (h), map panels (m), and political areas (p), listed in Table 4. Additional files included the entire data set for each category listed in Table 4 with a prefix of vb signifying the difference. The Arc Interchange naming conventions were as follows: the first five characters are the county name, the next two characters are the sheet number, and the last character is the file category. The readme statement shown in Appendix H provides more detail about the DFIRM sheets.

Table 4. Arc Interchange (e00)

vabch01e	vabch04e	vabch06p	vabch09p	vabch12p
vabch01f	vabch04f	vabch07f	vabch10e	vb_24k
vabch01h	vabch04h	vabch07h	vabch10f	vb_erm
vabch01m	vabch04m	vabch07m	vabch10h	vb_fall
vabch01p	vabch04p	vabch07p	vabch10m	vb_hall
vabch02e	vabch05e	vabch08e	vabch10p	vb_mall
vabch02f	vabch05f	vabch08f	vabch11e	vb_pall
vabch02h	vabch05h	vabch08h	vabch11f	
vabch02m	vabch05m	vabch08m	vabch11h	
vabch02p	vabch05p	vabch08p	vabch11m	
vabch03f	vabch06e	vabch09e	vabch11p	
vabch03h	vabch06f	vabch09f	vabch12f	
vabch03m	vabch06h	vabch09h	vabch12h	
vabch03p	vabch06m	vabch09m	vabch12m	

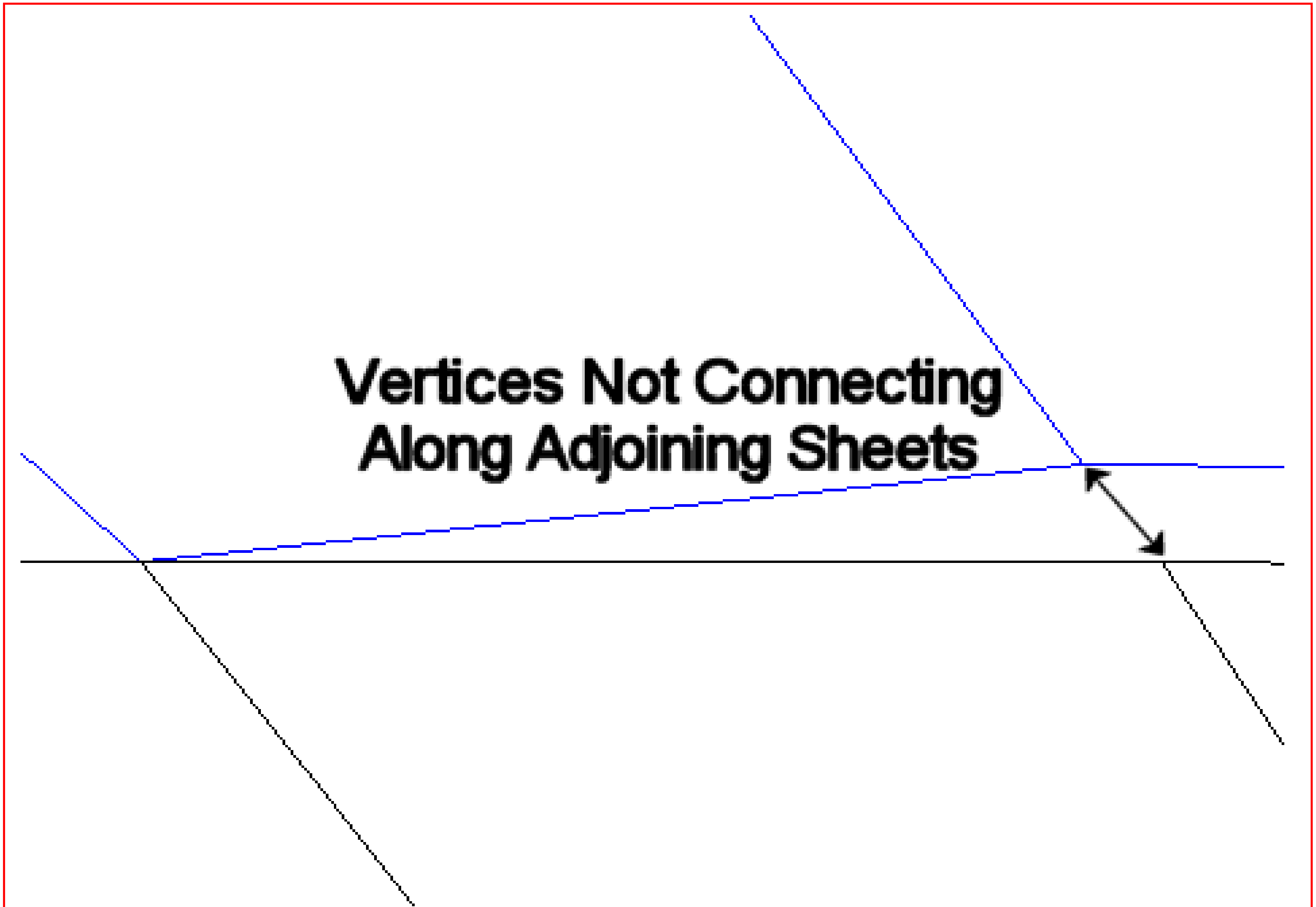


Figure 10. Vector Problem with DLG DFIRMs

The DLG DFIRM AMLs were edited to import the Arc Interchange files into ArcInfo. The AMLs were changed to accept the new naming convention, seen in Appendixes I, J, K, and L. The one major change to the AMLs was the replacement of the *DLGARC* with the *IMPORT* command to accept the Arc Interchange files. A new AML was written to import Elevation Reference Marks (ERM), seen in Appendix M. The vector sheets were viewed in ArcEdit with adjoining sheets to search for errors found in the first DLG DFIRMs. No anomalies were present in the second DFIRM delivery.

ANALYSIS

The analysis included mapping specific items of the DFIRMs to IFSAR products. Elevation data and feature comparisons were the two main categories of the analysis. The elevation comparison was focused on the ERMs and the IFSAR DEM. The feature comparison looked into how closely the hydrography category appeared to converge with features seen in the ORI. Quattro Pro 9, ArcInfo 8.0.1, and Corpscon 5.11.08 for Windows were used for the analysis.

Processing ERM and IFSAR DEM

The ERM AML was used to import the Arc Interchange files and assign character attributes to the data set. There were 70 ERMs for the 12 DFIRMs, with only 48 ERMs covering the IFSAR collection area, shown in Figure 11. The 48 ERMs were clipped to the IFSAR collection area. The *ADDXY* command was used to add x,y coordinates to the 48 points for further processing. In TABLES, the clipped ERM coverage was selected and the *UNLOAD* command was used to dump the xyz data to an ASCII file for analysis using the string *unload ermngvd29.txt x-coord y-coord elev delimited*. The 48 ERMs were in the NAD 27 and NGVD 29 datums, shown in Appendix N. The ERMs were projected to the North American Datum of 1983 (NAD 83), and North American Vertical Datum of 1988 (NAVD 88) to match the datum of the IFSAR DEM using Corpscon software available on the TEC Web site at http://crunch.tec.army.mil/software/corpscon/corpscon.html. ERM height values are shown in Table 5 under columns DFIRM NGVD29 and DFIRM NAVD88.

The x,y coordinates from the projected ERMs were used with an AML, shown in Appendix O, to extract elevation values from the IFSAR DEM. The IFSAR coordinates and elevation values were dumped into an ASCII file for analysis. The IFSAR elevation values were in meters and the ERMs elevation values were in feet. The IFSAR elevation values were converted to feet using Corpscon software. Quattro Pro was used to check the Corpscon conversion using the formula m * 3937/1200 to obtain exact values for the IFSAR elevation values. In Table 5, the old and new IFSAR elevation values can be seen in columns IFSAR Meters and IFSAR Feet.

Preliminary Datum Comparison

The first analysis looked at the differences between datum elevations, seen in Table 5 under columns DFIRM NGVD29 and DFIRM NAVD88. The basic statistics for the datum differences, seen in Table 6 under column NGVD29-NAVD88, were a mean value of 0.94 ft, maximum value of 1.12 ft, minimum value of 0.81 ft, and standard deviation of 0.11 ft. In Figures 12 and 13, the datum differences between NAVD29 and NAVD88 can be seen and are fairly homogeneous depending on general location of the points. The main problem with converting from NGVD29 to NAVD88 is the establishment of orthometric heights in the area. The National Geodetic Survey (NGS) has not supported the NGVD29 vertical datum for the last

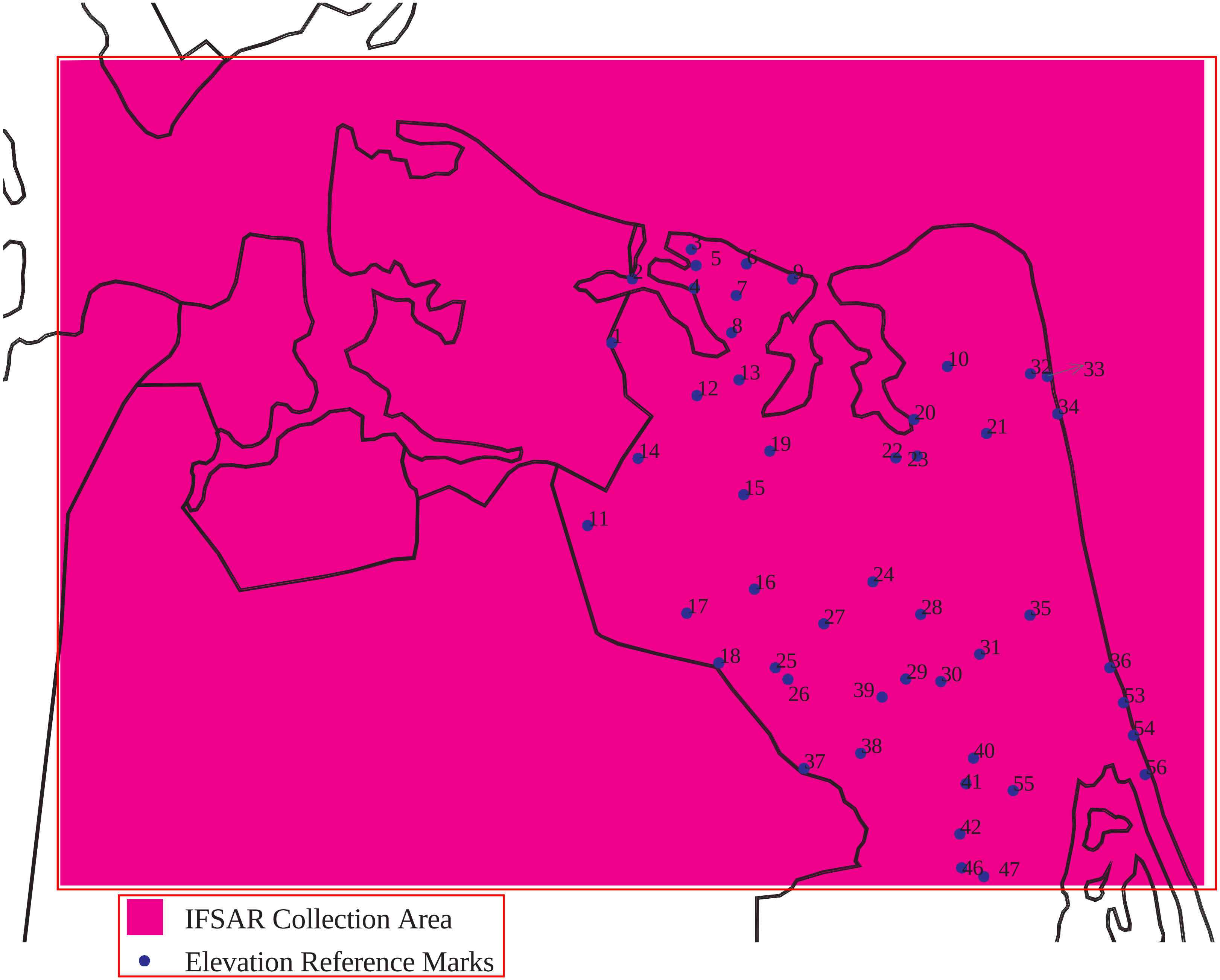


Figure 11. ERMs Within the IFSAR Collection Area

10 years. Benchmarks may be suspect as to the actual horizontal and vertical accuracy. A High Accuracy Reference Network (HARN) is needed to tie into to help update older benchmarks using the *NOAA Technical Memorandum NOS NGS-58: Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2 cm AND 5 cm) Version 4.3*.

Elevation Analysis

The next analysis addresses the differences between the IFSAR DEM and the newly converted ERM NAVD88 elevations. The differences between columns GEOID96 Feet and DFIRM NAVD88 are shown in Table 6. In Figures 14 and 15, the extremely variable differences are seen with nine values less than 1 ft; the remaining 39 values are more than 1 ft. Further investigation was needed to determine why the IFSAR DEM differed from the ERM NAVD88 elevations. The height differences were from buildings and forest canopies in highly urbanized areas. The IFSAR system collects data at a resolution of 2.5 m and the IFSAR DEM was produced and delivered at 5 m. The Observations column in Table 6 lists the possible causes of the height differences observed in the analysis. The main categories listed are forest (For), structure (Stru), voids, and water, with abbreviated combinations of each. The three best and worst differences will be shown to illustrate what the investigation found. Buildings will appear in the ORI as bright white, forested areas as lighter tones of gray, water and roads as black. The IFSAR DEM was converted to a color-shaded-relief to represent different changes in elevation. ArcEdit was used to plot each ERM over the magnitude and color-shaded-relief images to show what the investigation found.

Summary Analysis

The three best ERMs were found to be ERM 55 with 0.09 ft or approximately 1 inch, ERM 15 with 0.15 ft or approximately 1.8 inches, and ERM 41 with 0.46 ft or approximately 5.5 inches. In Figure 16, ERM 55 is shown as a magenta color with the magnitude and color-shaded-relief side-by-side images. ERM 55 is close to a forested section seen in the ORI with a road running between forested sections. The color-shaded-relief image shows the road has disappeared from view because of the processing of the IFSAR DEM to 5 m. ERM 55 had the lowest height difference of any point and is attributed to its location near an agricultural and rural area. ERM 15 seen in Figure 17 was the best point found in an urban area due to its location near a transportation feature. The buildings and forest canopy near ERM 15 could possibly be affecting the IFSAR DEM. In Figure 18, ERM 41 was located in an agricultural and rural area with minor residential development seen in the ORI. The forest canopy was a possible cause of the elevation difference with ERM 41.

The three worst ERMs were ERM 29 with 43.64 ft, ERM 21 with 28.65 ft, and ERM 5 with 27.23 ft. ERM 29 in Figure 19 was the worst point of the comparison. This was mainly due to the forest canopy and possibly data dropouts seen in the ORI as black areas. The forest canopy is clearly affecting the IFSAR DEM in this location seen in the color-shaded-relief. In Figure 20, the IFSAR DEM was affected by the forest canopy in the area of ERM 21. The IFSAR DEM

Table 5. IFSAR DEM and ERM Heights

NAD83 x-coord	NAD83 y-coord	ERM Identifier	IFSAR Meters	IFSAR Feet	DFIRM NGVD29	DFIRM NAVD88
393409.37973	4082805.83270	1	6.3080	20.6955	20.71	19.87
394307.49802	4085591.52714	2	-0.3670	-1.2041	12.79	11.95
396874.85194	4086875.05312	3	7.3780	24.2060	18.52	17.67
397001.98449	4085186.53175	4	1.8210	5.9744	9.76	8.90
397079.77849	4086175.81475	5	11.0440	36.2335	9.85	9.00
399273.22748	4086245.00284	6	1.5430	5.0623	9.91	9.06
398829.63262	4084872.41502	7	-1.6050	-5.2657	11.88	11.02
398627.37158	4083252.71472	8	9.5640	31.3779	20.23	19.38
401287.72958	4085586.81242	9	4.9430	16.2172	6.35	5.51
408019.98137	4081786.76947	10	10.5420	34.5865	23.76	22.94
392357.14375	4074861.96580	11	4.9590	16.2697	18.04	17.19
397118.37701	4080516.77227	12	4.8790	16.0072	17.58	16.73
398949.86789	4081203.06194	13	8.1300	26.6732	26.47	25.63
394556.65444	4077783.89734	14	3.4070	11.1778	15.34	14.49
399152.98245	4076206.39426	15	3.0580	10.0328	10.80	9.88
399617.99304	4072093.28068	16	2.5520	8.3727	11.04	10.01
396673.00733	4071045.96544	17	6.7730	22.2211	9.86	8.89
398074.27240	4068885.38444	18	10.8850	35.7119	10.57	9.54
400288.59432	4078104.08520	19	4.8170	15.8038	15.97	15.12
406568.20028	4079479.14320	20	9.0920	29.8293	16.69	15.88
409722.94886	4078870.16070	21	12.0520	39.5406	11.71	10.89
405774.51625	4077808.12393	22	1.7630	5.7841	18.87	18.04
406701.86713	4077889.88166	23	6.8410	22.4442	18.87	18.04
404774.97851	4072417.56854	24	2.8970	9.5046	14.28	13.28
400529.37587	4068676.73248	25	4.0610	13.3235	11.47	10.39
401075.66444	4068170.23380	26	8.5400	28.0183	11.56	10.47
402640.16089	4070589.02789	27	4.0810	13.3891	13.95	12.88

NAD83 x-coord	NAD83 y-coord	ERM Identifier	IFSAR Meters	IFSAR Feet	DFIRM NGVD29	DFIRM NAVD88
406859.65941	4070996.82929	28	6.7080	22.0078	10.99	10.00
406207.35873	4068186.04911	29	15.5130	50.8956	8.35	7.26
407734.68321	4068081.06769	30	4.5920	15.0656	7.18	6.09
409422.06397	4069264.09679	31	7.3230	24.0255	17.01	15.98
411635.80979	4081461.68222	32	5.2520	17.2309	11.46	10.64
412368.52244	4081349.25025	33	7.2450	23.7696	8.05	7.23
412822.09919	4079719.53672	34	5.1480	16.8897	13.83	13.00
411610.92939	4070959.94322	35	2.3230	7.6214	6.20	5.27
415086.47948	4068678.72381	36	4.1170	13.5072	7.56	6.64
401777.63693	4064291.03898	37	-0.8530	-2.7986	2.43	1.31
404243.68979	4064954.78910	38	10.2750	33.7106	9.85	8.73
405176.58641	4067402.24954	39	4.2090	13.8090	15.86	14.75
409153.94202	4064742.51957	40	6.7250	22.0636	19.47	18.37
408832.70449	4063631.87659	41	3.7490	12.2998	12.94	11.84
408561.88182	4061441.06560	42	5.3780	17.6443	15.87	14.78
408642.63246	4059968.87470	46	4.3330	14.2159	14.26	13.19
409608.90667	4059588.08334	47	3.0610	10.0426	6.19	5.13
415684.41136	4067157.35210	53	3.7290	12.2342	12.04	11.10
416118.20805	4065734.66688	54	4.3000	14.1076	10.56	9.61
410880.84844	4063334.19477	55	1.2700	4.1667	5.16	4.08
416631.30942	4064029.86330	56	0.2400	0.7874	10.33	9.37
		Mean	5.3041	17.4017	12.9671	12.0213
		Max	15.5130	50.8956	26.4700	25.6300
		Min	-1.6050	-5.2657	2.4300	1.3100
		STD	3.4964	11.4711	4.9445	4.9851

Table 6. IFSAR DEM and ERM Differences

NAD83 x-coord	NAD83 y-coord	ERM Identifier	NGVD29 - NAVD88	IFSAR - NAVD88	Observations
393409.37973	4082805.83270	1	0.84	0.8255	Forest
394307.49802	4085591.52714	2	0.84	-13.1541	Structure
396874.85194	4086875.05312	3	0.85	6.5360	Forest
397001.98449	4085186.53175	4	0.86	-2.9256	Structure
397079.77849	4086175.81475	5	0.85	27.2335	Forest
399273.22748	4086245.00284	6	0.85	-3.9977	Structure
398829.63262	4084872.41502	7	0.86	-16.2857	For/Stru
398627.37158	4083252.71472	8	0.85	11.9979	Forest
401287.72958	4085586.81242	9	0.84	10.7072	Forest
408019.98137	4081786.76947	10	0.82	11.6465	Forest
392357.14375	4074861.96580	11	0.85	-0.9203	For/Stru
397118.37701	4080516.77227	12	0.85	-0.7228	Forest
398949.86789	4081203.06194	13	0.84	1.0432	Forest
394556.65444	4077783.89734	14	0.85	-3.3122	Structure
399152.98245	4076206.39426	15	0.92	0.1528	Structure
399617.99304	4072093.28068	16	1.03	-1.6373	Structure
396673.00733	4071045.96544	17	0.97	13.3311	Forest
398074.27240	4068885.38444	18	1.03	26.1719	Forest
400288.59432	4078104.08520	19	0.85	0.6838	Structure
406568.20028	4079479.14320	20	0.81	13.9493	Forest
409722.94886	4078870.16070	21	0.82	28.6506	Forest
405774.51625	4077808.12393	22	0.83	-12.2559	Structure
406701.86713	4077889.88166	23	0.83	4.4042	For/Stru
404774.97851	4072417.56854	24	1.00	-3.7754	For/Stru
400529.37587	4068676.73248	25	1.08	2.9335	For/Stru
401075.66444	4068170.23380	26	1.09	17.5483	Forest
402640.16089	4070589.02789	27	1.07	0.5091	Structure

NAD83 x-coord	NAD83 y-coord	ERM Identifier	NGVD29-NAVD88	IFSAR - NAVD88	Observations
406859.65941	4070996.82929	28	0.99	12.0078	Forest
406207.35873	4068186.04911	29	1.09	43.6356	For/Voids
407734.68321	4068081.06769	30	1.09	8.9756	For/Stru
409422.06397	4069264.09679	31	1.03	8.0455	Forest
411635.80979	4081461.68222	32	0.82	6.5909	For/Stru
412368.52244	4081349.25025	33	0.82	16.5396	Forest
412822.09919	4079719.53672	34	0.83	3.8897	Structure
411610.92939	4070959.94322	35	0.93	2.3514	Structure
415086.47948	4068678.72381	36	0.92	6.8672	For/Stru
401777.63693	4064291.03898	37	1.12	-4.1086	Forest
404243.68979	4064954.78910	38	1.12	24.9806	For/Voids
405176.58641	4067402.24954	39	1.11	-0.9410	For/Stru
409153.94202	4064742.51957	40	1.10	3.6936	Structure
408832.70449	4063631.87659	41	1.10	0.4598	Structure
408561.88182	4061441.06560	42	1.09	2.8643	Structure
408642.63246	4059968.87470	46	1.07	1.0259	Forest
409608.90667	4059588.08334	47	1.06	4.9126	Forest
415684.41136	4067157.35210	53	0.94	1.1342	Structure
416118.20805	4065734.66688	54	0.95	4.4976	Structure
410880.84844	4063334.19477	55	1.08	0.0867	Forest
416631.30942	4064029.86330	56	0.96	-8.5826	Stru/Water
		Mean	0.9458	5.3805	
		Max	1.1200	43.6356	
		Min	0.8100	-16.2857	
		STD	0.1101	11.1901	

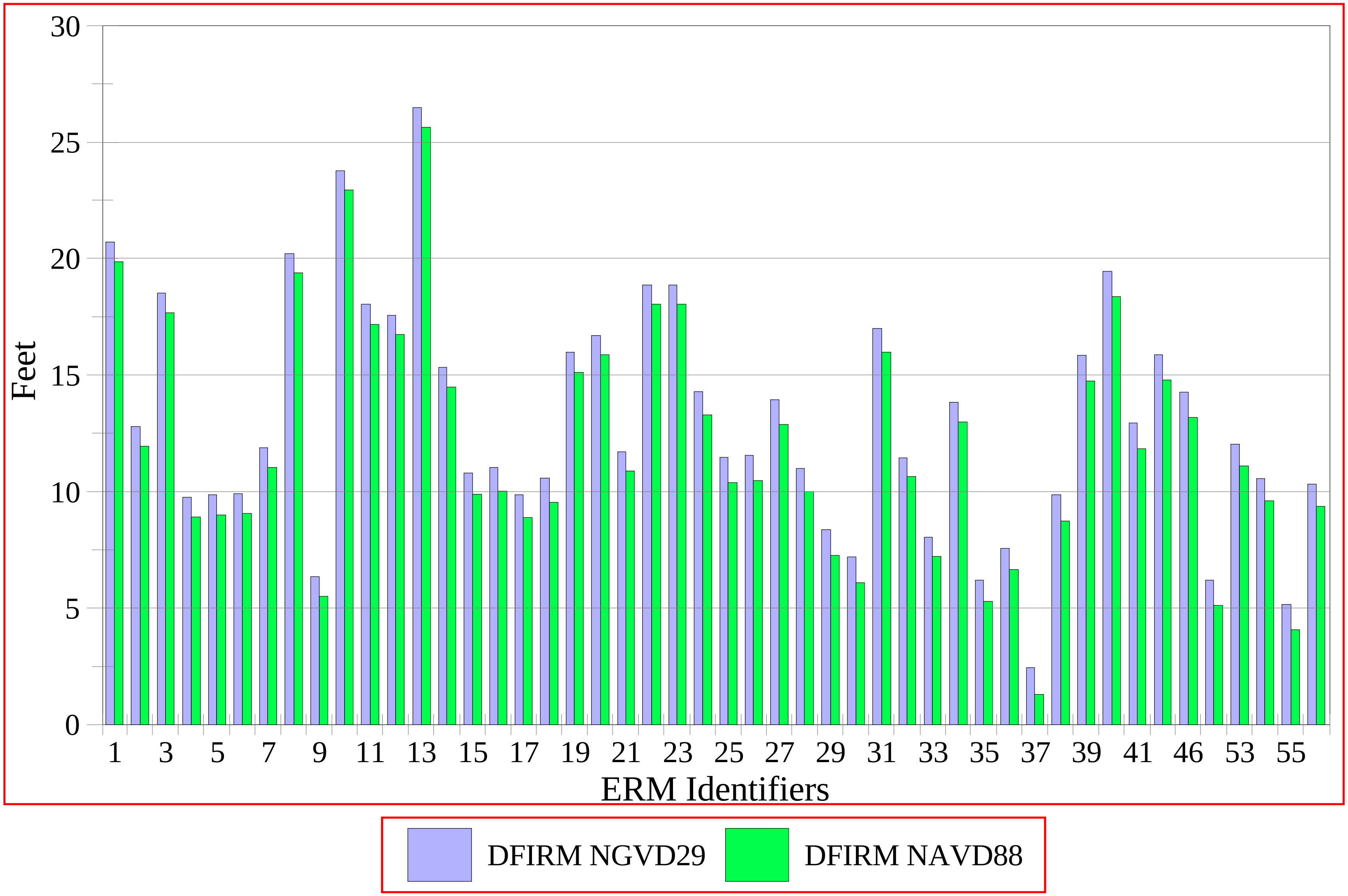


Figure 12. Vertical Datum Comparison NGVD29 AND NAVD88

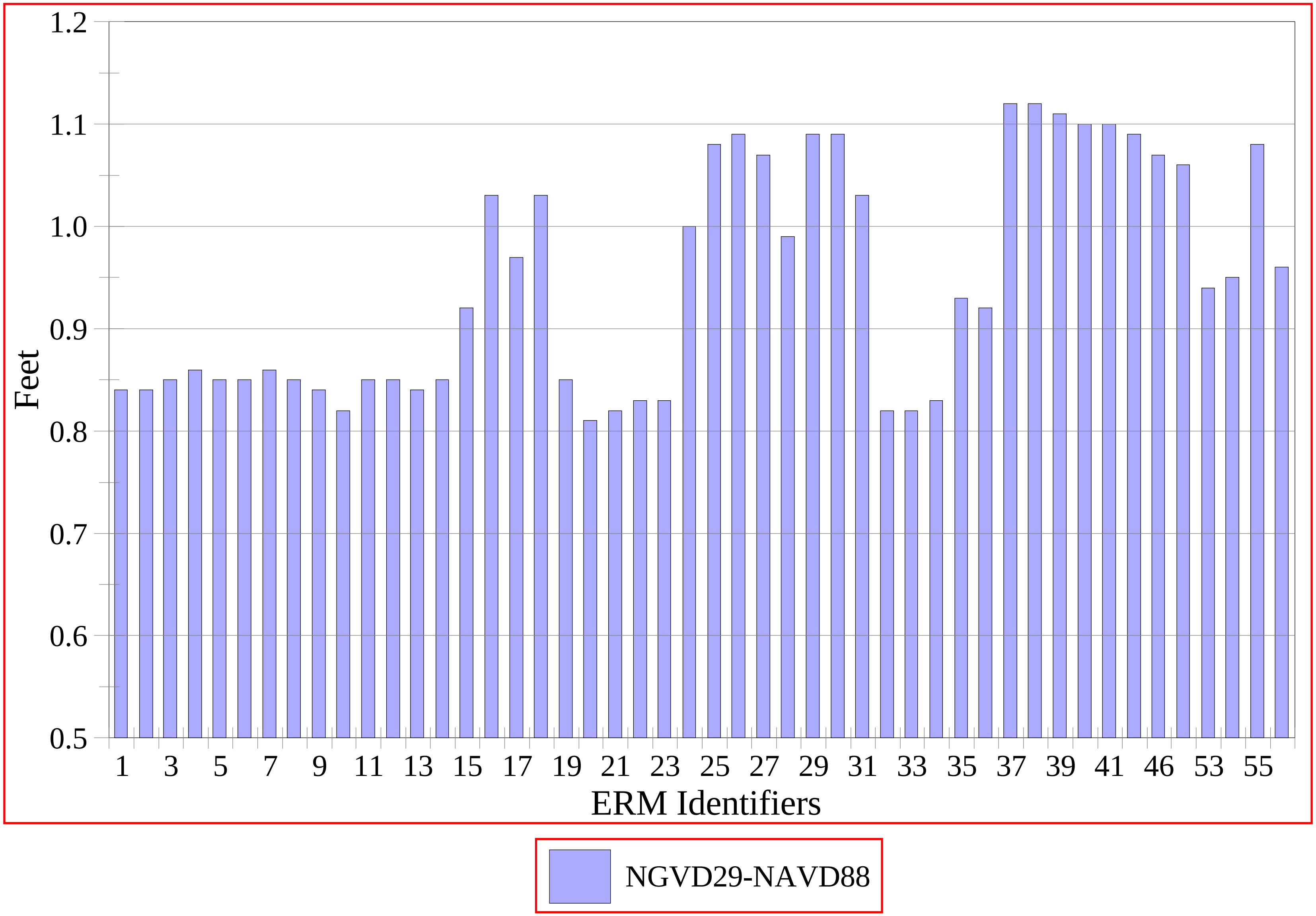


Figure 13. Difference Between DFIRM NGVD29 and NAVD88

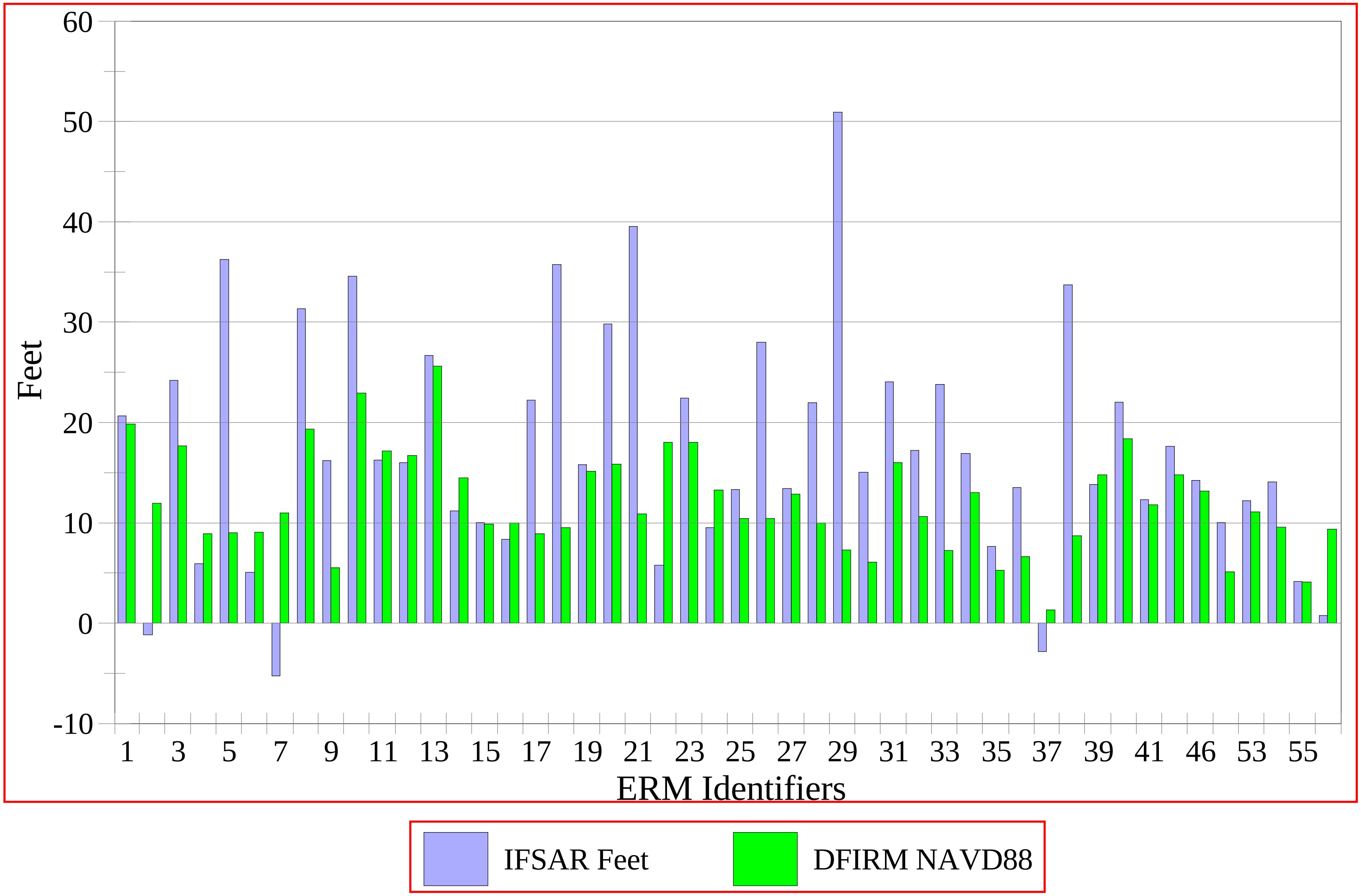


Figure 14. Orthometric Height Comparison

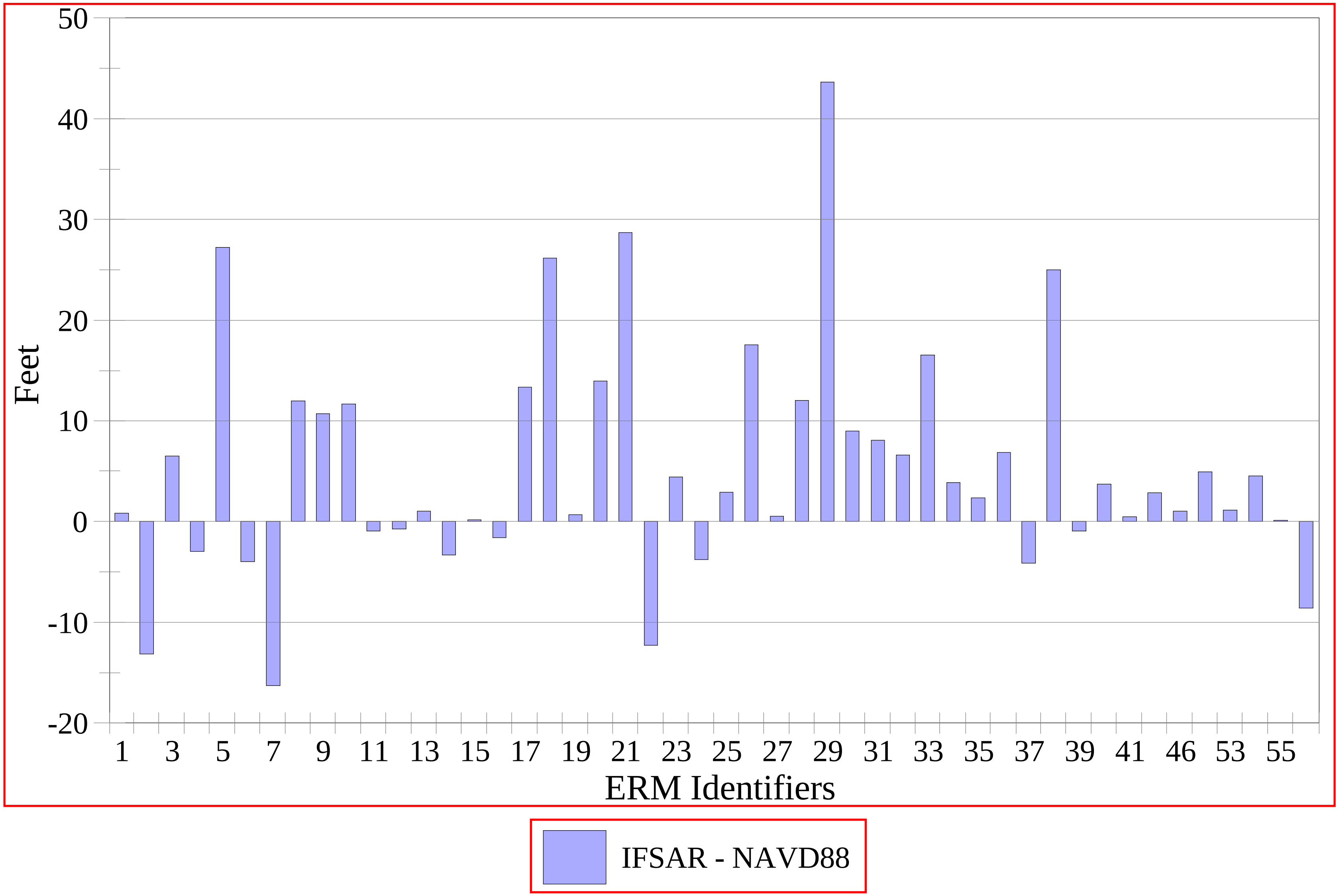
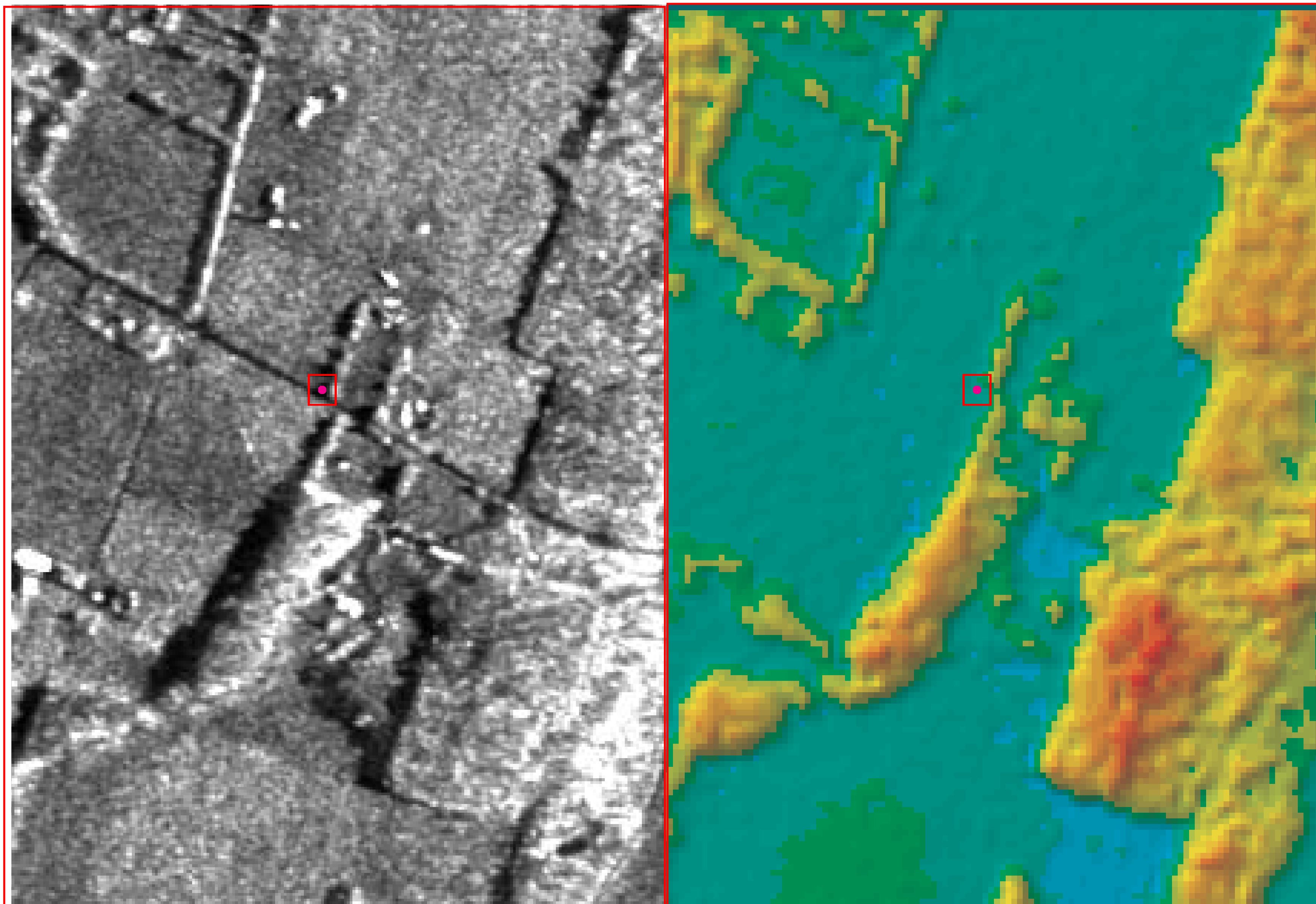


Figure 15. Difference Between IFSAR Feet and DFIRM NAVD88



Magnitude Image

Shaded Relief

Figure 16. ERM 55 with a 1-Inch Elevation Difference

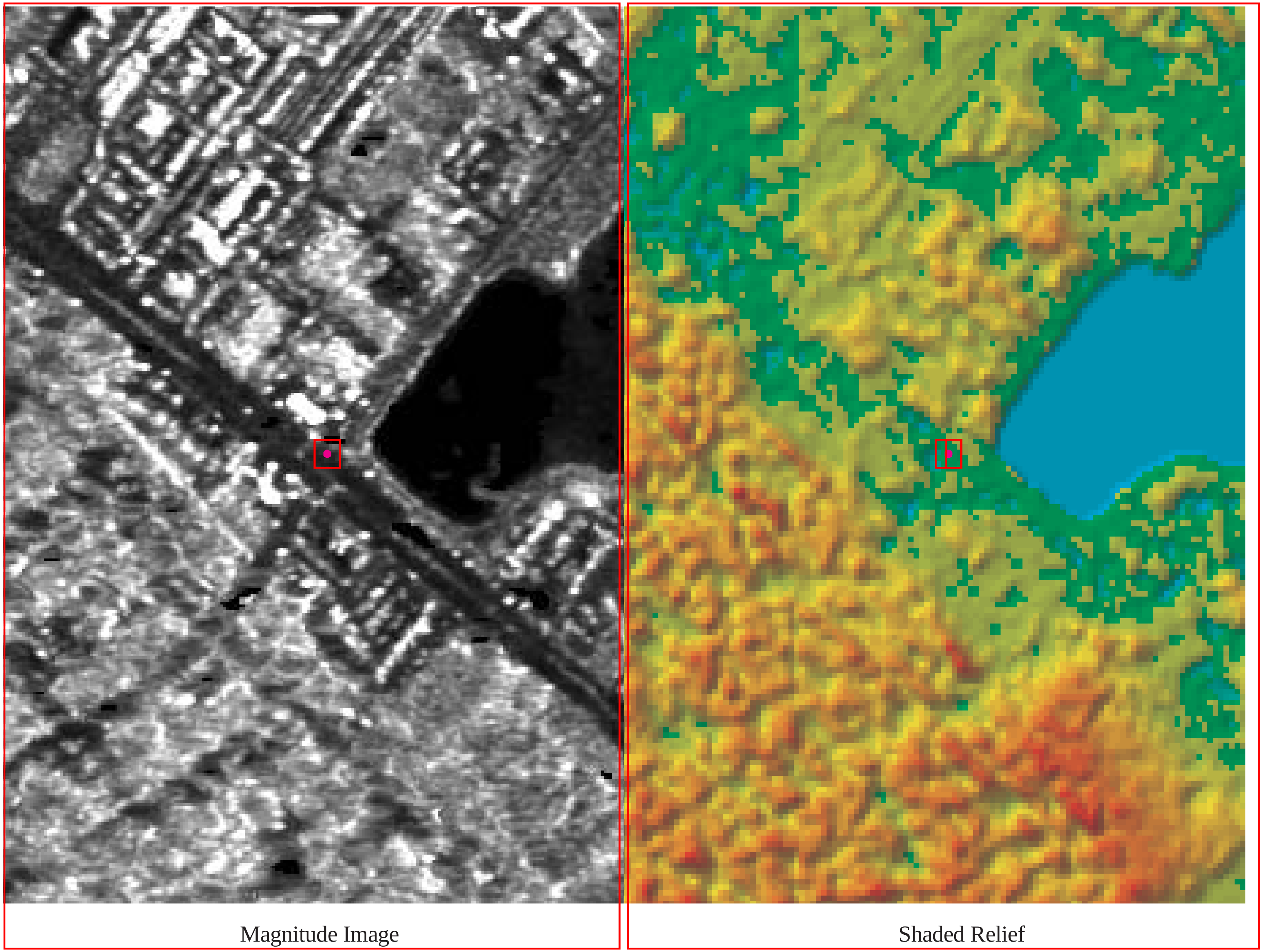
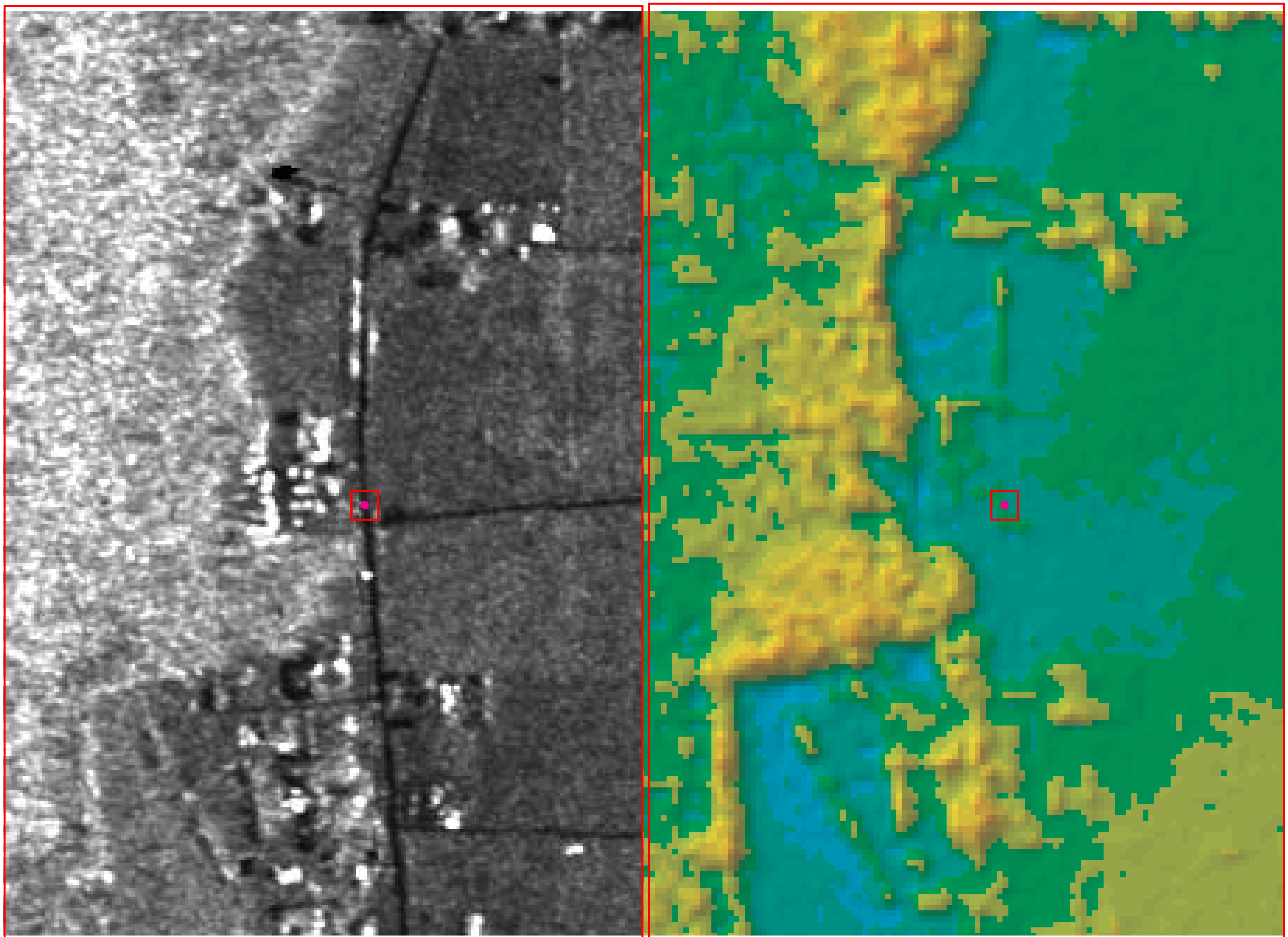


Figure 17. ERM 15 with a 1.8-Inch Elevation Difference



Magnitude Image

Shaded Relief

Figure 18. ERM 41 with a 5.5-Inch Elevation Difference

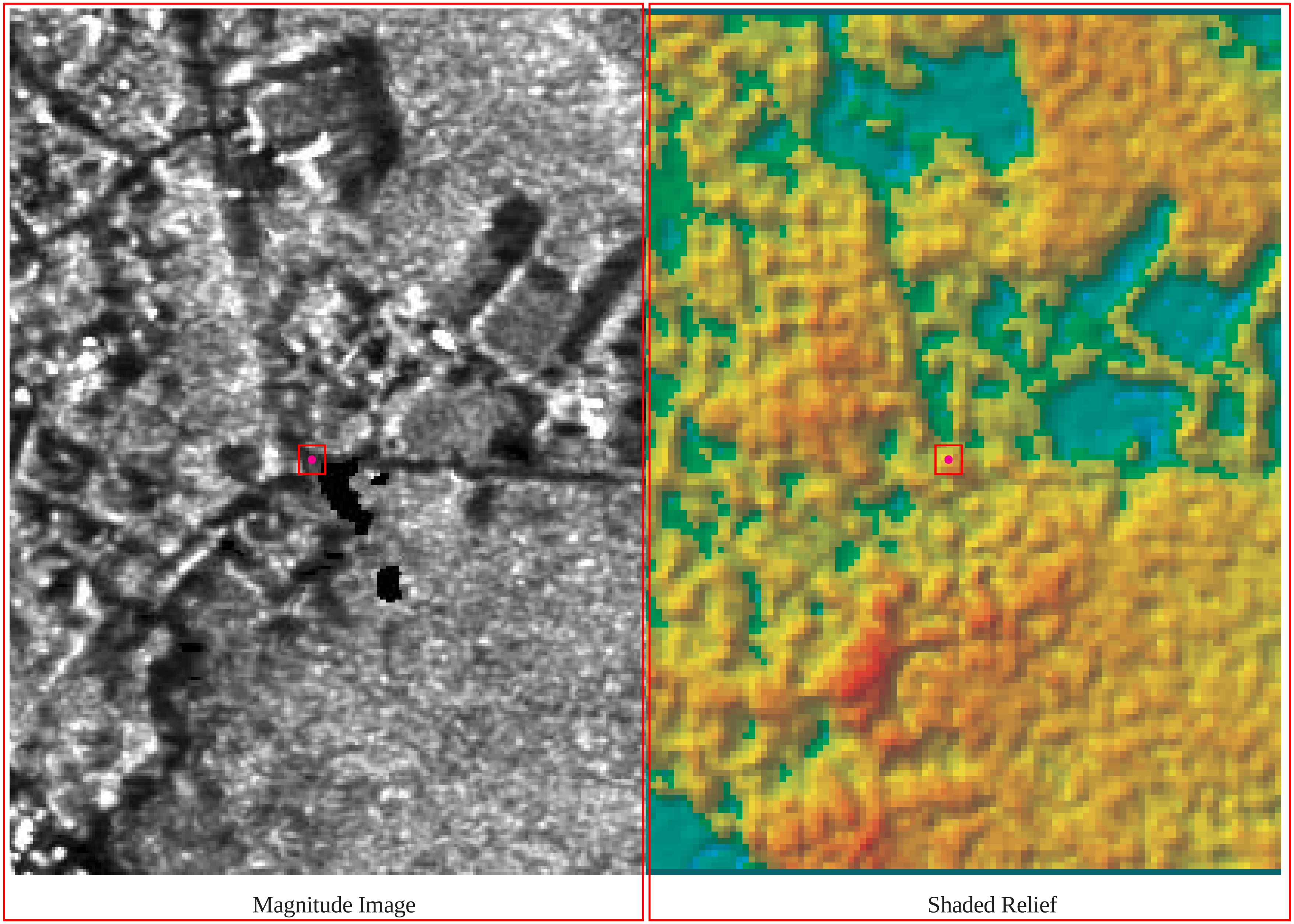
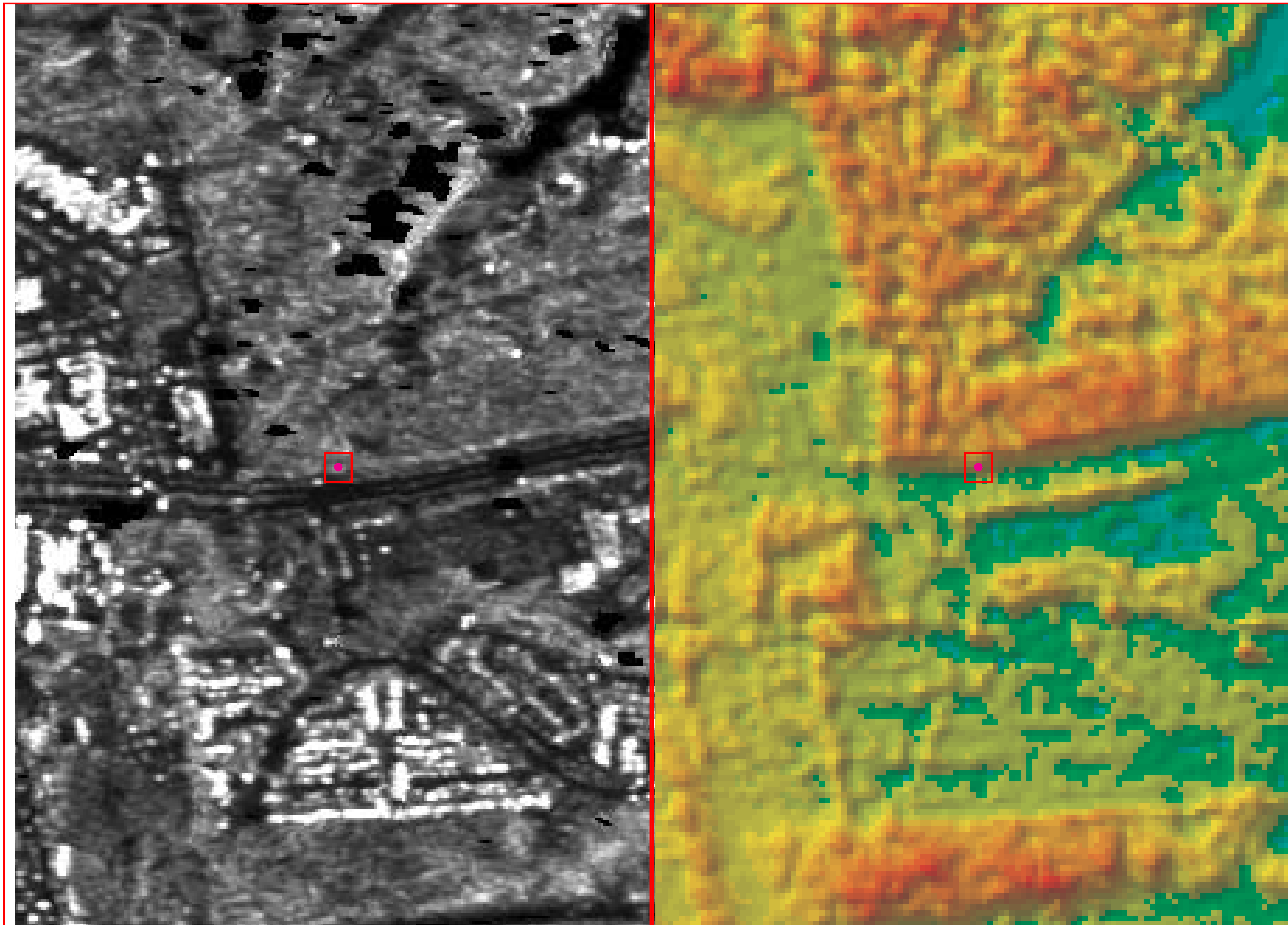


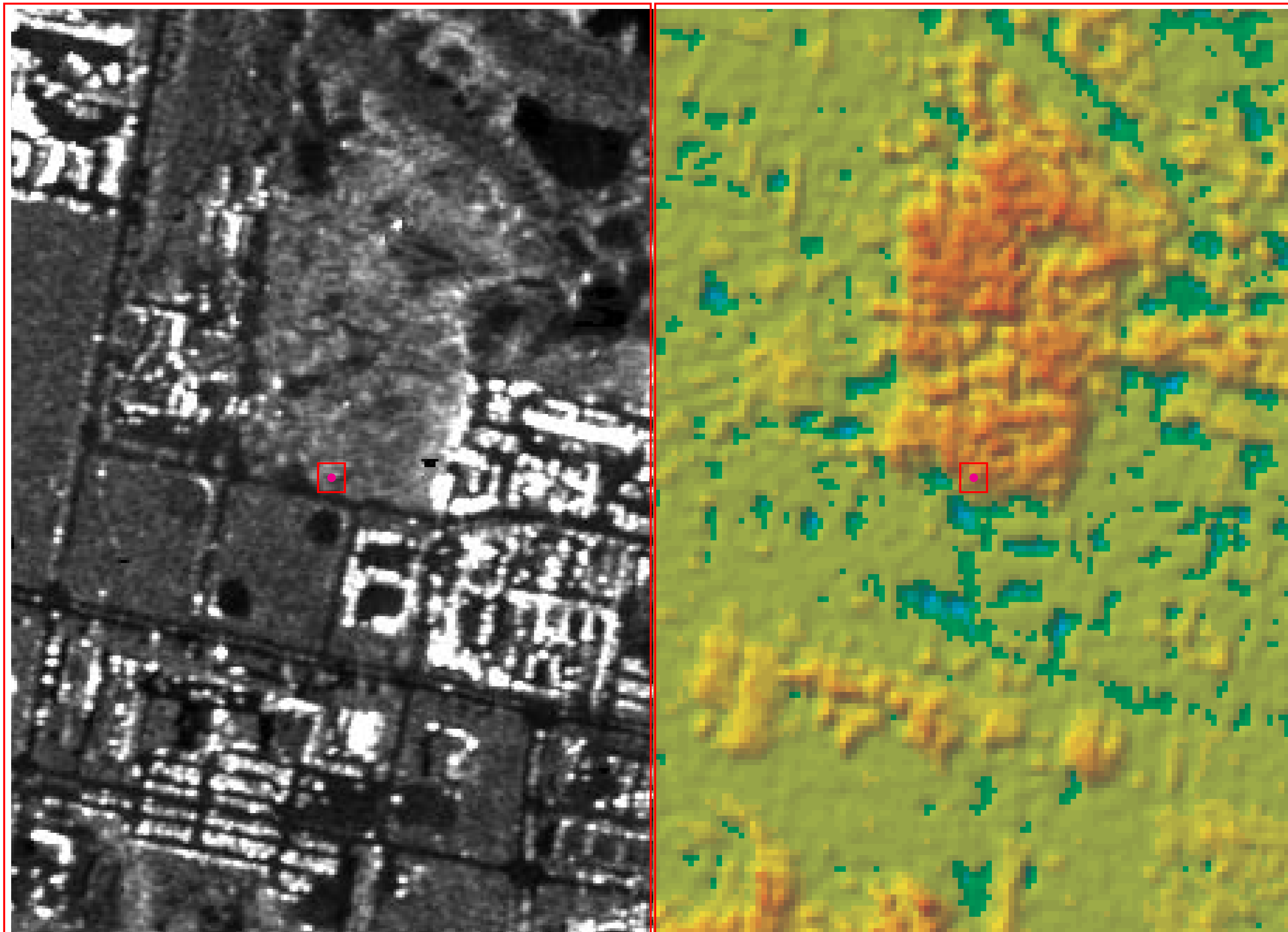
Figure 19. ERM 29 with a 43.64-Feet Elevation Difference



Magnitude Image | Shaded Relief

Figure 20. ERM 21 with a 28.65-Feet Elevation Difference

located around ERM 5 was affected by the forest canopy shown in Figure 21. The forest canopy was the main cause of height difference in the three locations shown in Figures 19, 20, and 21. These large height differences seen in Table 6 were mainly due to the highly forested urban areas of Virginia Beach and possibly the DEM being processed to 5 m. Intermap is developing techniques to produce a bald earth DEM, which might improve the height differences seen in the IFSAR DEM and NAVD88 ERM comparison.



Magnitude Image

Shaded Relief

Figure 21. ERM 5 with a 27.23-Feet Elevation Difference

DFIRM Verification

The main DFIRM vector categories — flood hazard, hydrography, political areas, and map panels — are based on the DLG-3 format and the standard USGS 7.5-minute 1:24,000-scale quad. The first step was to determine how accurate the panels were by generating USGS 7.5-minute quad corner points. The four corner coordinates of eleven USGS 7.5-minute quads were manually generated for the analysis seen in Table 7. These generate corner points were used as the known control for this analysis. The x,y geographic coordinates of each quad corner were typed into a text file and given a reference number. The precision of the data was set to double double by using the *PRECISION* command. The *GENERATE* command with the input and point option was used to import the coordinates of each quad into ArcInfo. The USGS-generated corner points were combined into one coverage and projected to the UTM, Zone 6, and NAD83 coordinate system used for the study, thus providing a better way to measure distances.

Table 7. Generated USGS 7.5-minute Quads

Cape Henry	North Bay
Creeds	North Virginia Beach
Fentress	Pleasant Ridge
Kempsville	Princess Anne
Knotts Island	Virginia Beach
Little Creek	

The DFIRM vb_24k vectors were chosen to represent the DFIRM corner coordinates and should be the same for all DFIRM categories. The *ARCPOINT* command was used to convert the boundary lines to four corner points needed for the comparison. The DFIRM corner points were projected to the UTM, Zone 6, and NAD83 coordinate system used for the study. The analysis used the *POINTDISTANCE* command to measure and compare the DFRIM vb_24k points to the USGS-generated corner points.

The results of the analysis seen in Appendix P were converted from meters to feet and inches with an average distance of 4.5 in., minimum distance of 4.17 in., and maximum distance of 4.84 in. between the two sets of corner points. The other DFIRM categories were found to be consistent with these findings. The corner points are within the 40-ft specification outlined in *Digital Line Graphs 1:24,000-Scale Maps* (USGS) and *Standards for Digital Flood Insurance Rate Maps* (FEMA). It was not required to calculate a root-mean-square value (RMS) with each point fallen within inches of another.

Hydrography and ORI

This part of the analysis looked into the relative horizontal and positional accuracy of the DFIRM hydrography category compared to the IFSAR ORI. ArcEdit was used for the analysis to overlay the hydrography vectors onto the west look ORI. Coastlines, river boundaries, and structures were investigated to determine relative accuracy.

In Figure 22, the hydrography vectors do not match the river boundary. At the top center of Figure 22, the green arrows are displaying a distance of more than 45 m from the left river boundary line shown in magenta and the river seen in the ORI. The green circle is displaying what looks like an island splitting the river. The hydrography vectors in Figure 23 do not match the ORI very well. The green circle shows the river edge curving while the hydrography line is fairly straight. Other hydrography lines are as much as 25 m from the river boundary. In Figure 24, the large island is clearly not represented by the hydrography line and other smaller islands are omitted. The hydrography line representing the bend in the river boundary does not depict what is seen in the ORI. The hydrography lines, shown in Figure 25, are offset horizontally by as much as 20 m. The orange line indicates where the center line is located in the ORI.

The hydrography vectors representing the shoreline do not match what is seen in the ORI in Figure 26. The hydrography line is more than 45 m from the visible edge of the coast in some places seen in the ORI. In Figure 27, the hydrography coastlines do not visibly match many of the islands seen in the ORI. These inaccuracies may be due to tidal differences, different generation of the DLG lines used in this DFIRM, generalization of the hydrography lines, or environmental factors such as vegetation and temporal changes within the islands.

Structures are an important element in the hydrography vectors. Coastal hard points, which can be piers, ripraps, and other structures, are some of the other elements of the hydrography vectors. In Figure 28, the piers seen in magenta have been mapped in the hydrography vectors, but many of the pier structures remain unmapped as seen in the ORI. The horizontal position of the mapped pier structures is offset as much as 8 to 15 m. The channel is not accurately mapped to the boundary, clearly seen in the ORI. The pier structures show a positional offset and some structures are unmapped as well in Figure 29. The mapped shoreline is also not as accurate as it appears in the ORI.

What can be done? It is clear that the ORIs from the IFSAR collection could be used to manually update the hydrography vectors using GIS software. The coastal hard points, stream and river boundaries, and shoreline features can be mapped accurately using the ORI, which portray current features. While most of the hydrography vectors are within the DLG-3 standards, some vectors do appear outside the standard using the prior figures as examples. The horizontal accuracy and alignment of features could increase from the DLG-3 standard of 40 ft per 1/50th of an inch on hard copy (FEMA) to 2.5 m or 8.2 ft using ORIs as a guide. Other important considerations are the length of time and cost that would be involved to update the current inventory of hydrography vectors using the DLG-3 standard if the ORIs were available.

Figure 22. Hydrography Offset Along River Channel

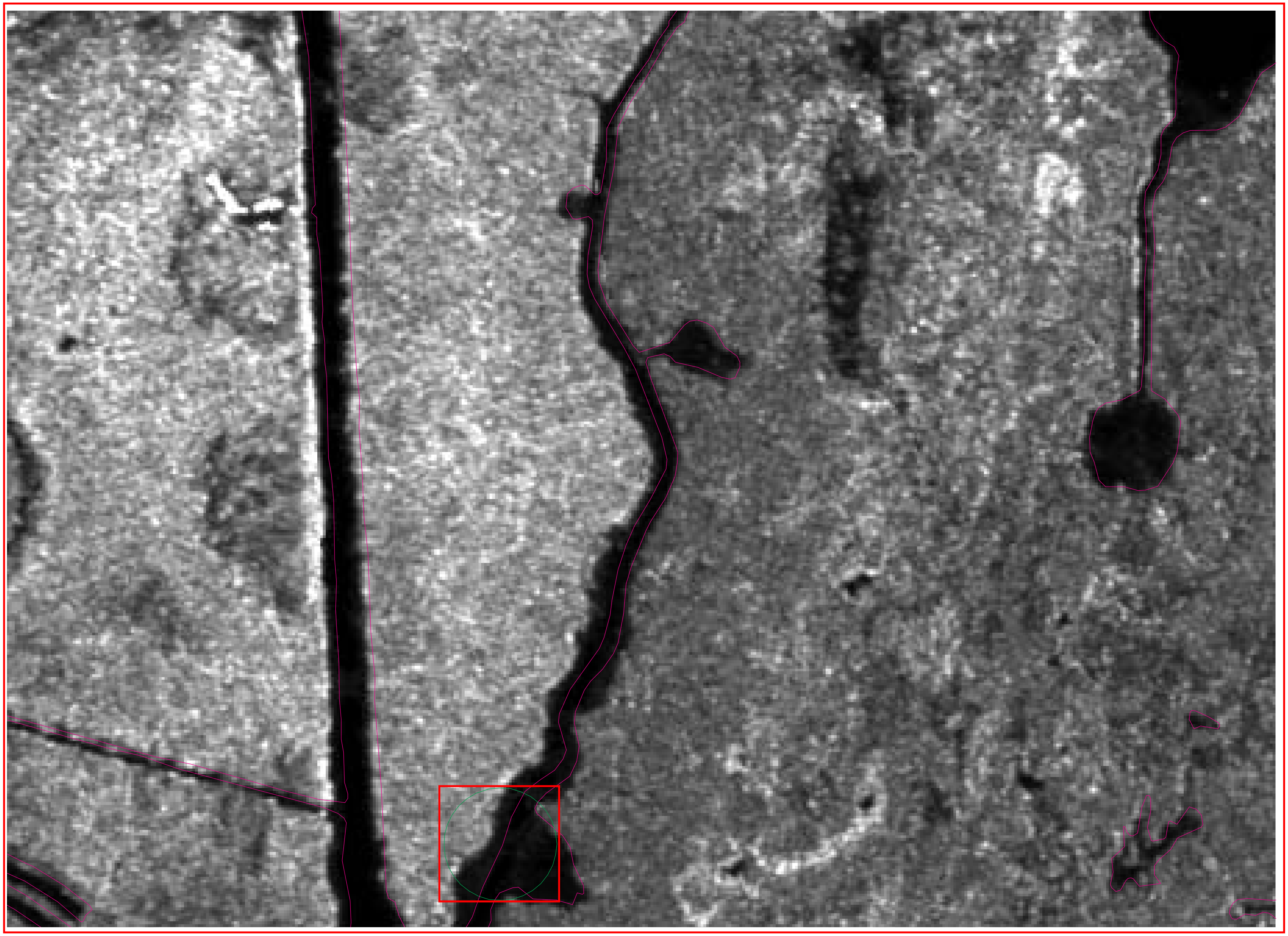


Figure 23. Hydrography Offset Along Channel Boundaries

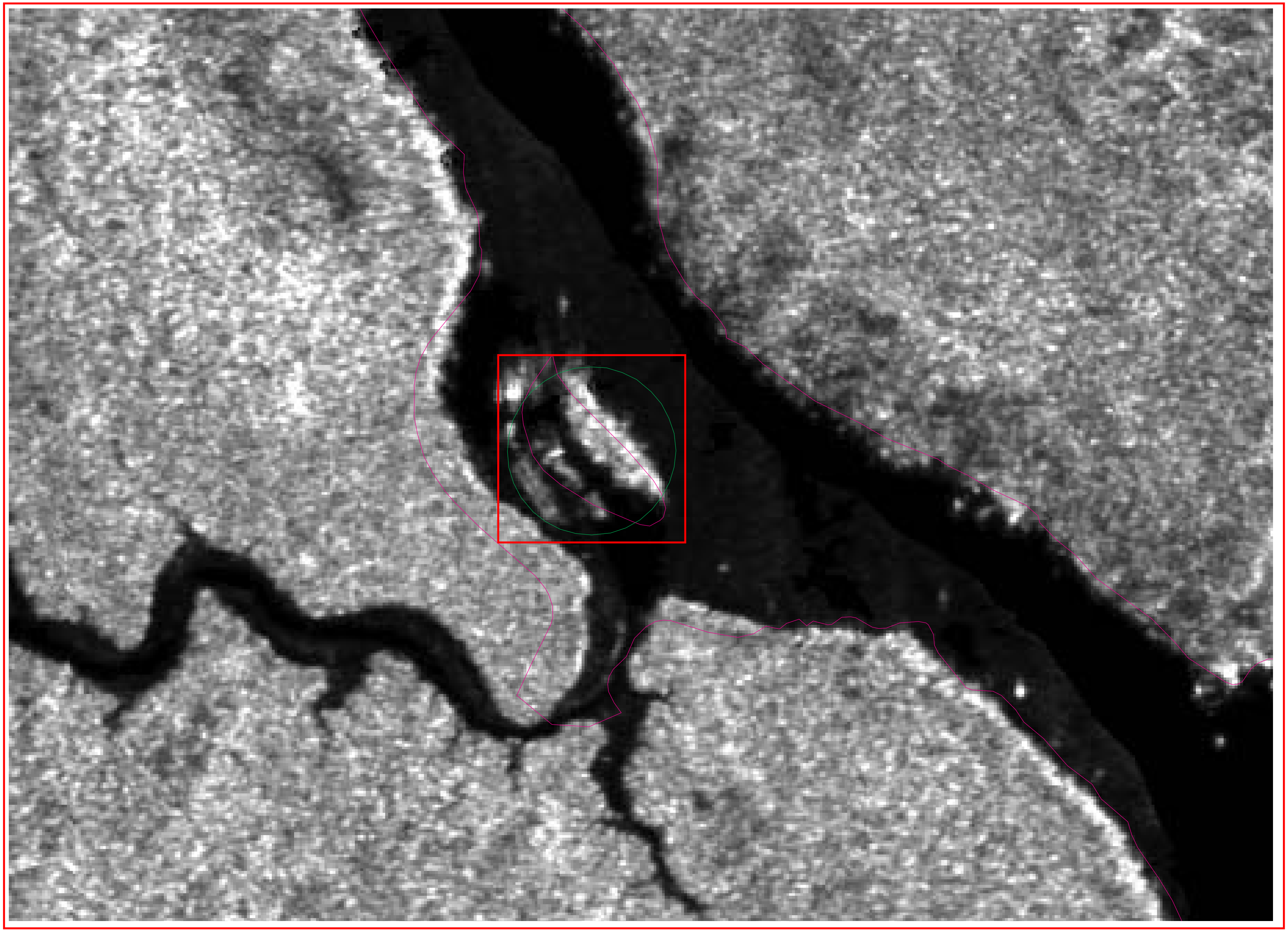


Figure 24. Hydrography Offset and Single Island Boundary

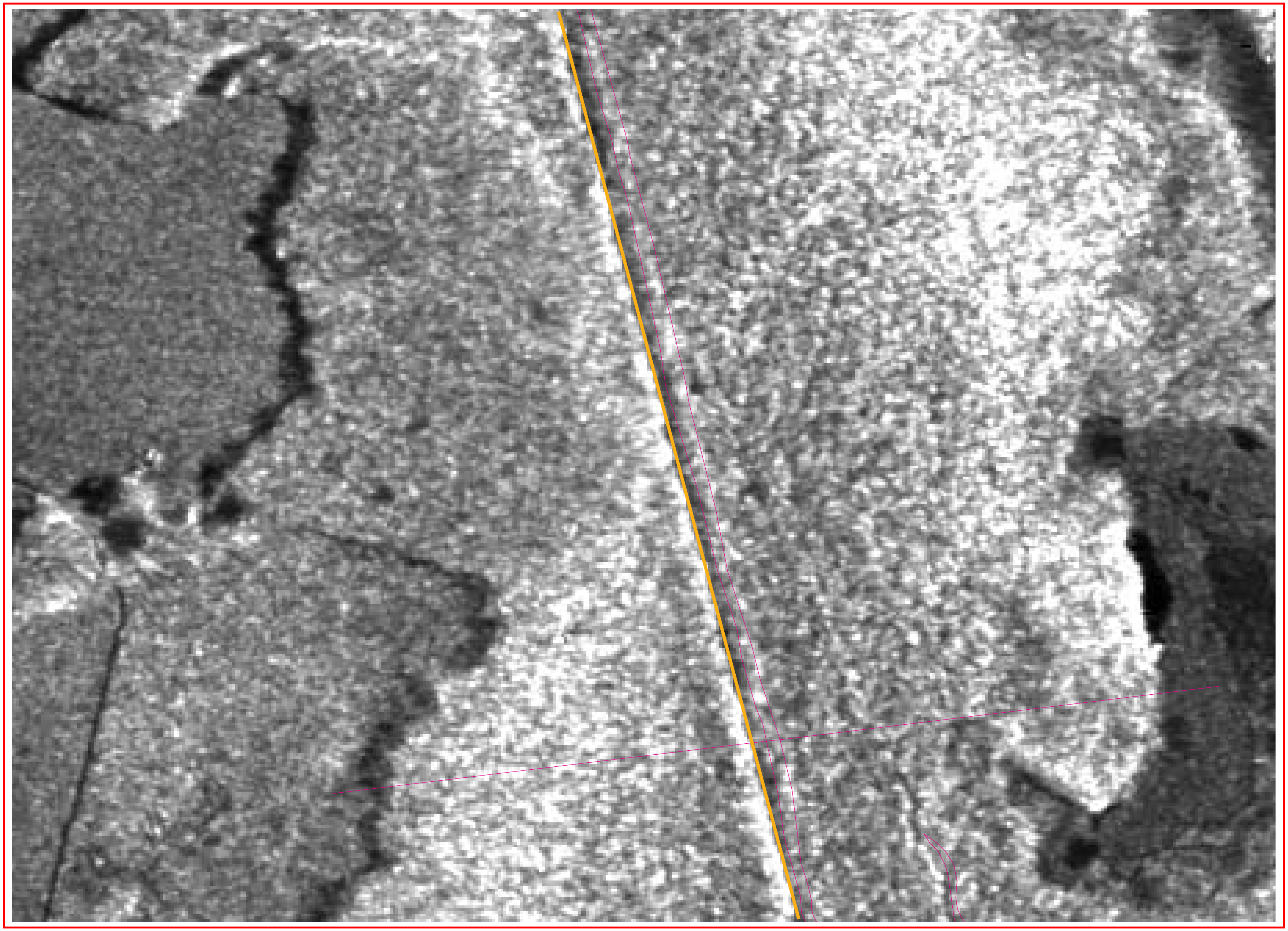


Figure 25. Hydrography Offset Along Channel Boundary

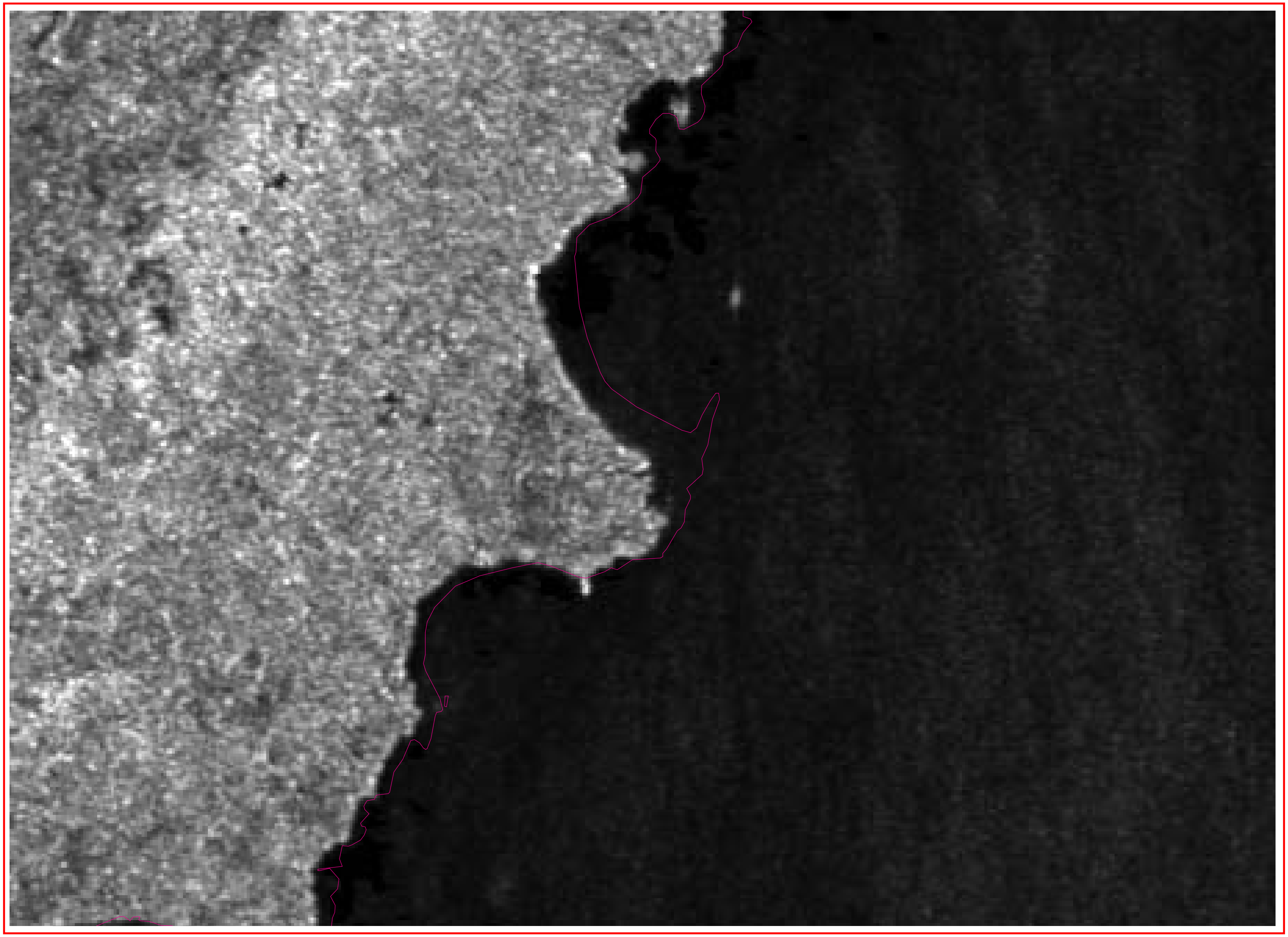


Figure 26. Hydrography Offset Along Shoreline

Figure 27. Hydrography Offset Along Multiple Shorelines

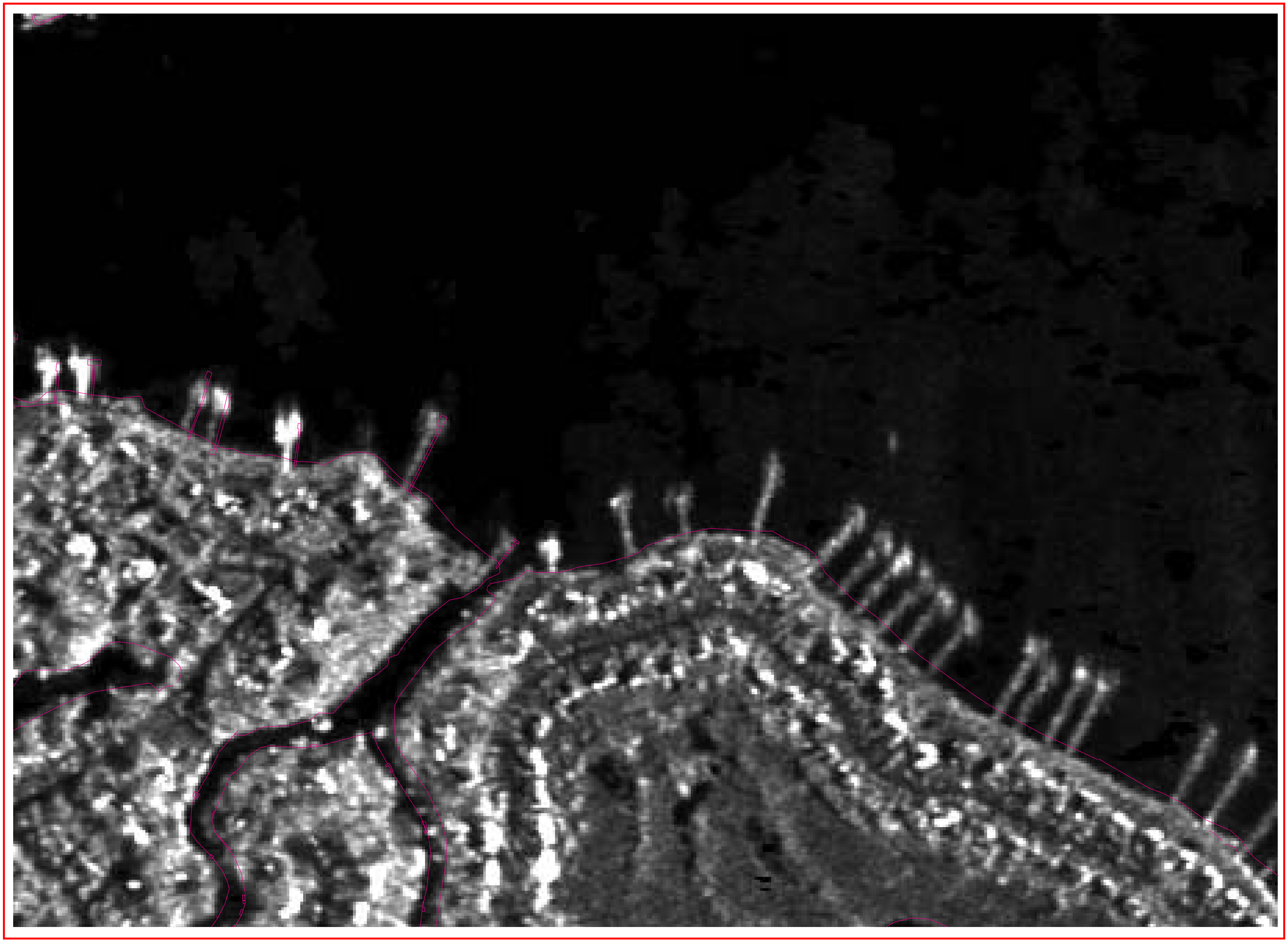


Figure 28. Hydrography - Offset and Missing Pier Vectors

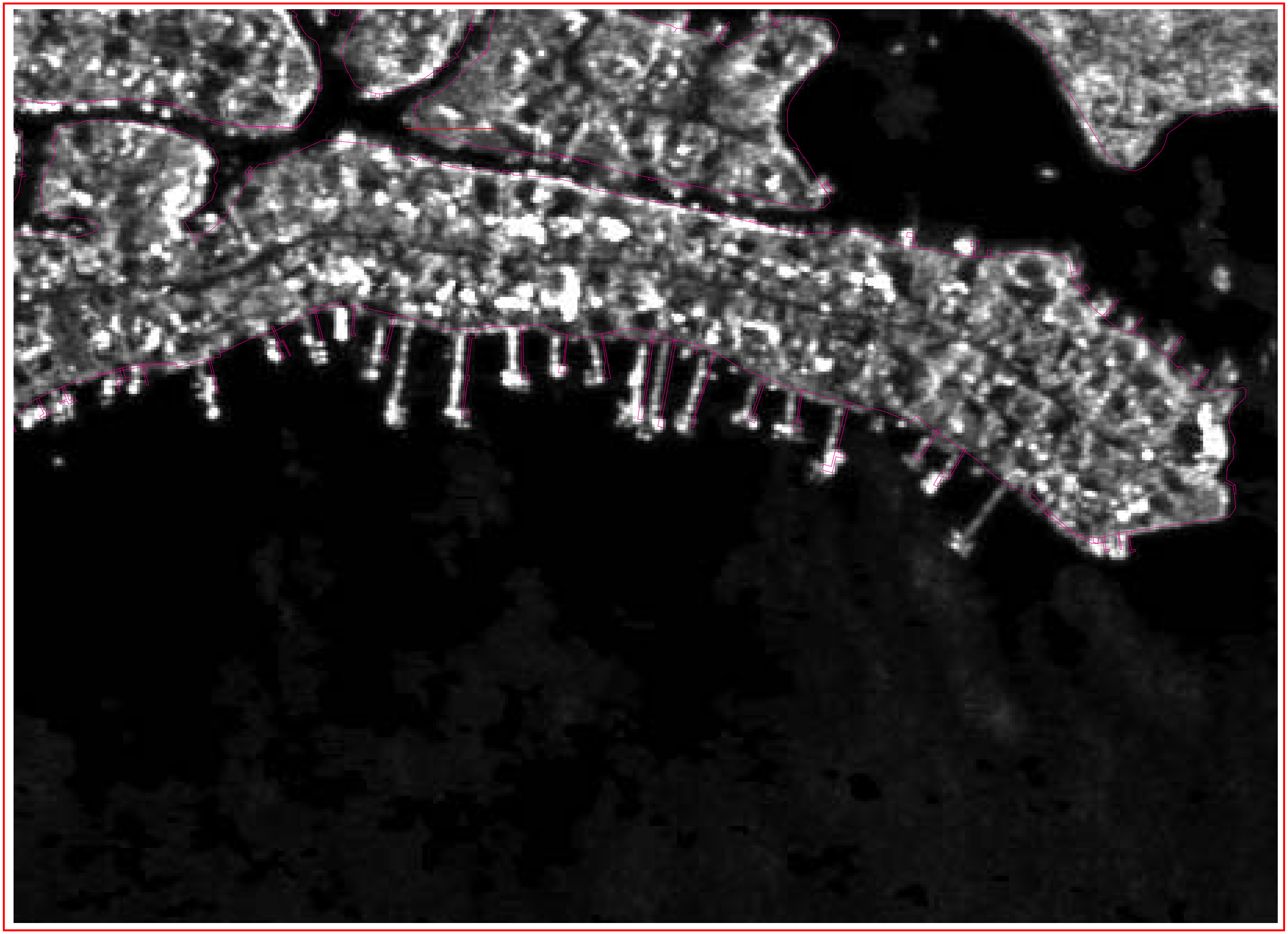


Figure 29. Hydrography - Pier Offset

DFIRM specifications and procedures call for the use of Digital Orthophoto Quarter Quadrangles (DOQs) produced by the USGS to be the default base map if suitable community data are not available (FEMA). Information on DFIRMs specifications can be found at http://www.fema.gov/mit/tsd/MM_WIP5g.htm. With the DOQ production taking as long as 12 to 14 months (FEMA), IFSAR ORIs can be produced within two to three months for large areas. The ORI contains more information than a DOQ and is also horizontally more accurate. The horizontal accuracy of the USGS DOQs is roughly 38 ft RMS. The IFSAR ORI with a horizontal accuracy of 2.5 m or 8.2 ft RMSE could be as much as 2.5 to 5 times more accurate than the USGS DOQ depending on quality of the control used to produce the DOQ product.

CONCLUSIONS

The digital age has come to FEMA with the production of DFIRMs. The Virginia Beach DFIRMs are formatted on the DLG-3 standard with its own attribution scheme based on the technical document *Standards for Digital Flood Insurance Rate Maps* (FEMA). A DFIRM DLG and Arc interchange file (e00) formats were delivered to TEC for the purpose of this study. The first DLG was only partially finished and had several errors requiring extensive work to correct. Some of the errors included node, vertex, and alignment, which involved vectors from adjoining sheets. The first DLG version was found to be an intermediate version with numerous problems with vectors of adjoining sheets. The e00 files lacked the problems associated with the DLG files. The e00 files were easier to import with the same attribution as the DLG version. AMLs were written to import the DLG and e00 files into ArcInfo for the investigation. These AMLs are provided in appendixes D, E, F, G, I, J, K, L, and M and are available for open and free distribution.

The Virginia Beach DFIRMs were based on the horizontal datum NAD27 and vertical datum NAVD29. One problem with current DFIRM ERMs is the possibility that the markers are no longer located in their original position, and worse, cannot be found. ERMs in the NAD27 and NAVD29 datums may not convert easily to the accepted NAD83 and NAVD88 datums. The DFIRM ERMs do not contain information on the NGS benchmarks, which could be used to find the marker in the field and for updating future DFIRMs. The ERMs were projected to horizontal datum NAD83 to match the IFSAR DEM horizontal datum WGS84. Corpscon was used to project the ERMs to the NAD83 and NAVD88 datums with units in feet for the vertical height comparison. The IFSAR DEM height values were extracted using an AML and the units converted to feet using Corpscon. The ERMs and the IFSAR DEM height values were investigated and the highest level of confidence came from areas with little to no forest cover and no interfering urban structures. Since the IFSAR collection device is not a vegetation penetration system, forest canopies will affect the elevation values. Some of the ERMs came very close to the IFSAR DEM values and warrant further investigation. Intermap is perfecting a production method to produce a bare earth DEM product, which should be similar to the LIDAR bare earth DEM product. More information on the IFSAR bald earth DEM is located at http://www.intermap.ca/HTML/research_new_bald.htm. The IFSAR bald earth DEM could possibly help in the future determination of the flood plain within urban areas. At present, the IFSAR DEM is not suitable for flood plain mapping in predominately forested and urbanized areas.

The hydrography vectors are based on the DLG-3 specifications and can come from multiple data sources. This can create position problems for the user of the hydrography vectors. Hydrography features covered by forest canopies and less than 2.5 m wide cannot be easily distinguished using the IFSAR ORIs. The IFSAR ORI can be used to identify shorelines, coastal hard points (piers), and river boundaries out of alignment and easily edited to match current features using GIS. There are still questions of money and time associated with updating hydrography vectors using ORIs if made available. Nevertheless, the resolution of the ORI at 2.5

m or 8.2 ft is sufficient to update the current DLG-3 hydrography vectors used in the Virginia Beach DFIRMs.

The IFSAR DEM and ORI products could support efforts involved with the production of DFIRM 2.0 and DFIRM 2.1 products, which have been combined into a single product (FEMA). Further information on the DFIRM 2.0 and 2.1 specifications is located at http://www.fema.gov/mit/tsd/MM_WIP3f.htm. The minimal standards for base maps used for DFIRMs under the DFIRM 2.0 and 2.1 specifications are the 1-m resolution USGS-produced DOQs. The ORI resolution of 2.5 m does not meet this part of the DFIRM 2.0 and 2.1 standard, but still provides useful information to update hydrography vectors. The horizontal accuracy of the ORI product compared to the USGS DOQ could be as much as 2.5 to 5 times more accurate. The ORI product meets the DFIRM 2.0 and 2.1 file format specifications for base maps. The draft minimal standard for IFSAR DEMs is a DEM with a vertical accuracy of 15-cm RMSE and a maximum post spacing of 5 m. The IFSAR DEM product meets the 5-m resolution requirements for flood plain mapping, but does not meet the vertical height requirement. Intermap is researching a new product called Global Terrain Flood (GTF) with a proposed vertical accuracy of 50-cm RMSE. An independent review of the GTF product has not been taken and warrants further investigation, but should address FEMA’s vertical height requirement if successful.

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United States Naval Observatory. "USNO GPS Data & Information", http://192.5.41.239/gps_datafiles.html.

Appendix A. Header file for gt1n36w075h8m1.txt

Intermap Technologies Inc.
Global Terrain Metadata File (DEM)

File Creation date:	Wednesday, June 02, 1999
Tile Identifier #:	GT1N36W075H8V1.bil
Project Area:	Virginia Beach
Product Description	
Product Level:	GT1
DEM posting (meters):	5.0
Horizontal Accuracy:	2.5 meters (1 sigma)
Vertical Accuracy:	3 meters (1 sigma)
Sensor	
Data Source:	Intermap Star-3i Airborne Interferometric SAR
Flying Height:	20,000 ft. Above Mean Ground
Primary Look:	West
Alternate (Secondary)Look:	South
Mission #(s):	165
Acquisition Date:	3/10/99
Band:	X-Band
Processing	
Interpolation:	Continuous curvature spline over non-data areas
Phase Unwrapper:	Goldstein
Data Format, Parameters, and Coordinates	
Format:	32 bit BIL (float)
Projection:	UTM
Horizontal Datum:	WGS-84 Ellipsoid
Vertical Datum:	WGS-84 Ellipsoid
Geoid Model:	GEOID96
Vertical Reference:	Mean Sea Level (MSL)
Central Scale:	0.9996
UTM Zone:	18
Central Meridian:	75 degrees West
False Easting (meters):	500,000.0 meters
False Northing (meters):	0.0 meters
UTM Easting (meters):	Min. 410,307.50 Max. 419,197.50
UTM Northing(meters):	Min. 4,081,102.50 Max. 4,095,102.50
Pixel Origin:	Center Center
Pixels (columns):	1779
Lines (rows):	2801
Legacy Information	
Intermap Project Number:	98063

Flight Acquisition Manager:	J. Keith Tennant	403.266.0900
Denver Processing Center:	Ken Rath	303.708.0955
Ottawa Processing Center:	Ian Isaacs	613.226.5442
Metadata File Creator:	Tom Hutt	613.226.5442
Mississippi DHS Center:	Ron Birk	228.688.1465
Project Manager:	Cliff Holle	228.688.1783
Metadata File Description:	www.globalterrain.com	
Intermap Information:	www.intermaptechnologies.com	
ISO 9001 Certification No.	0411-069	

Appendix B. ifsargrid.aml

```
/*****************************************************************************
/*   IFSARGRID AML
/*   09/29/99
/*    POC:  James J. Damron
/*         U.S. ARMY Topographic Engineering Center (TEC)
/*         Terrain Research Division
/*         Terrain Representation Branch
/*         7701 Telegraph Road
/*         Alexandria, VA 22315-3864
/*
/*          (703) 428-8168 or 428-6838
/*          (703) 428-8176  FAX
/*
/*          jdamron@tec.army.mil
/*
/*    variables    ifsar - ifsar file names read
/*                 count - number of files completed
/*
/*    FLOATGRID is used to import IFSAR DEM because of the IEEE, 32 bit binary
/*    float format.
/*    A text file is used to import the files for the California Collection.
/*    A new text file can be used later to import different IFSAR collections.
/*    This AML works on a UNIX and NT workstations running ArcInfo.
/******************************************************************************

&severity &error &ignore
&severity &warning &ignore
&type haaa.... This is working...
display 9999
&term 9999

&sv file := [open [getfile *.txt -file] ok -r]
&sv ifsar = [read %file% readstatus]
&sv count = 1

&do &while %readstatus% eq 0

&type Processing IFSAR file %ifsar%
&type
&sys mv %ifsar%.bil %ifsar%.dem
&type

/* Converts IFSAR DEM to Arc GRID
floatgrid %ifsar%.dem dem%ifsar%
&type
```

```
&type
&type this many finished %count% and finished file %ifsar%
&sv count = %count% + 1
&sv ifsar = [read %file% readstatus]

&end

&return
```

Appendix C. Header file for im2n36w075h8m1.txt

Intermap Technologies Inc.
Global Terrain Metadata File (ORI)

File Creation date: Friday, May 28, 1999
Tile Identifier #: IM2N36W075H8V1.tif
Project Area: Virginia Beach

Product Description
Product Level: GT1
Image Pixels (meters): 2.5
Horizontal Accuracy: 2.5 meters (1 sigma)

Sensor
Data Source: Intermap Star-3i Airborne Interferometric SAR
Flying Height: 20,000 ft. Above Mean Ground
Primary Look: West
Alternate (Secondary)Look: South
Mission #(s): 165
Acquisition Date: 3/10/99
Band: X-Band

Processing
Interpolation: Continuous curvature spline over non-data areas
Phase Unwrapper: Goldstein

Data Format, Parameters, and Coordinates
Format: 8 bit GEOTIFF
Projection: UTM
Horizontal Datum: WGS-84 Ellipsoid
Vertical Datum: WGS-84 Ellipsoid
Geoid Model: GEOID96
Central Scale: 0.9996
UTM Zone: 18
Central Meridian: 75 degrees West
False Easting (meters): 500,000.0 meters
False Northing (meters): 0.0 meters
UTM Easting (meters): Min. 410,309.00 Max. 419,196.50
UTM Northing(meters): Min. 4,081,102.50 Max. 4,095,100.00
Pixel Origin: Upper Left
Pixels (columns): 3556
Lines (rows): 5600

Legacy Information
Intermap Project Number: 98063
Flight Acquisition Manager: J. Keith Tennant 403.266.0900

Denver Processing Center:	Ken Rath	303.708.0955
Ottawa Processing Center:	Ian Isaacs	613.226.5442
Metadata File Creator:	Tom Hutt	613.226.5442
Mississippi DHS Center:	Ron Birk	228.688.1465
Project Manager:	Cliff Holle	228.688.1783
Metadata File Description:	www.globalterrain.com	
Intermap Information:	www.intermaptechnologies.com	
ISO 9001 Certification No.	0411-069	

Appendix D. femafldhaz.aml

```
/*****************************************************************************
/* Developed to add attributes to DFIRM DLGs on 1 December 1999 for Digital
/* Flood Insurance Rate Maps
/* femafldhaz.aml (FLOOD HAZARD ZONES DLG files)
/* DLG files must be in same directory as this AML to work correctly
/* 1 December 1999 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/*****************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

&type
&type This might take some time on slower systems!!!!!
&type

&if [exists flood.txt -file] &then
&do
&type
&type File already exists.... deleting file flood.txt
&type
[delete flood.txt -file]
&end

[filelist *f*.dlg flood.txt -file]

&sv file := [open flood.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&sv temp1 = [substr %line% 1 5]
&sv temp2 = [substr %line% 6 3]
&sv line2 = %temp2%%temp1%
&type
&type Processing file %line%........
&type
dlgarc optional %line% %line2% %line2%pnt all
build %line2% line
clean %line2% %line2% # # poly
build %line2%pnt point
```

```
&end
/*********************************************************
/* Flood Hazard Lines
/*********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
ef arc
de arc
draw
sel major1 = 440 and minor1 = 0204
drawsel
calc majdescript1 = 'Apparent Limit'
sel major1 = 440 and minor1 = 0245
drawsel
calc majdescript1 = '100-Year Floodplain Boundary'
sel major1 = 440 and minor1 = 0246
drawsel
calc majdescript1 = '500-Year Floodplain Boundary'
sel major1 = 440 and minor1 = 0247
drawsel
calc majdescript1 = 'Zone Break'
sel major1 = 440 and minor1 = 0248
drawsel
calc majdescript1 = 'Zone D'
sel major1 = 440 and minor1 = 0249
drawsel
calc majdescript1 = 'Floodway'
sel major1 = 440 and minor1 = 0250
drawsel
calc majdescript1 = 'Flow Easement'
sel major1 = 440 and minor1 = 0251
drawsel
calc majdescript1 = 'Limit of Detailed Study'
```

```
sel major1 = 440 and minor1 = 0252
drawsel
calc majdescript1 = 'Limit of Floodway'
sel major1 = 440 and minor1 = 0253
drawsel
calc majdescript1 = 'Limit of Study'
sel major1 = 440 and minor1 = 0254
drawsel
calc majdescript1 = 'State Encroachment Line'
sel major1 = 440 and minor1 = 0256
drawsel
calc majdescript1 = '1983 Undeveloped Coastal Barrier Area Boundary'
sel major1 = 440 and minor1 = 0257
drawsel
calc majdescript1 = '1990 Undeveloped Coastal Barrier Area Boundary'
sel major1 = 440 and minor1 = 0258
drawsel
calc majdescript1 = 'Otherwise Protected Area Boundary'
sel major1 = 440 and minor1 = 0261
drawsel
calc majdescript1 = 'Base Flood Elevation (BFE) Line'
sel major1 = 440 and minor1 = 0262
drawsel
calc majdescript1 = 'Interpolated Base Flood Elevation (BFE) Line'
sel major1 = 440 and minor1 = 0270
drawsel
calc majdescript1 = 'Zone Bisector'
sel major1 = 440 and minor1 = 0299
drawsel
calc majdescript1 = 'Processing Line'
sel major1 = 440 and minor1 = 0600
drawsel
calc majdescript1 = 'Multiple Source Data'
sel major3 = 440 and minor3 = 0610
drawsel
calc majdescript3 = 'Feet'
sel major3 = 440 and minor3 = 0611
drawsel
calc majdescript3 = 'Meters'
sel major4 = 440 and minor4 = 0620
drawsel
calc majdescript4 = 'NGVD 29'
sel major4 = 440 and minor4 = 0621
drawsel
calc majdescript4 = 'NAVD 88'
sel major4 = 440 and minor4 = 0622
drawsel
calc majdescript4 = 'Other Vertical Datum'
```

```
sel major1 = 440 and minor1 = 0710
drawsel
calc majdescript1 = 'Floodway'
sel major1 = 440 and minor1 = 0712
drawsel
calc majdescript1 = 'Flow Easement'
sel major1 = 440 and minor1 = 0713
drawsel
calc majdescript1 = 'State Encroachment Area'
sel major2 = 440 and minor2 = 0246
drawsel
calc majdescript2 = '500-Year Floodplain Boundary'
sel major2 = 440 and minor2 = 0249
drawsel
calc majdescript2 = 'Floodway'
sel major2 = 441
drawsel
calc majdescript2 = 'Elevation'
sel major3 = 440 and minor3 = 0246
drawsel
calc majdescript3 = '500-Year Floodplain Boundary'
sel major3 = 444
drawsel
calc majdescript3 = 'Decimal Fractions'
sel major2 = 445
drawsel
calc majdescript2 = 'Depth'
sel major2 = 447
drawsel
calc majdescript2 = 'Negative Elevation'
sel major5 = 449
drawsel
calc majdescript5 = 'Velocity in Whole Feet per Second'
save
q
build %line2% line
&end
/*****************************************************
/* POLY
/*****************************************************
&if [exists %line2% -poly] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id
ae
mape %line2%
```

```
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
ef poly
de poly
draw
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
sel major1 = 440 and minor1 = 0150
drawsel
calc majdescript1 = 'Zone V'
sel major1 = 440 and minor1 = 0151
drawsel
calc majdescript1 = 'Zone VE'
sel major1 = 440 and minor1 = 0152
drawsel
calc majdescript1 = 'Zone A'
sel major1 = 440 and minor1 = 0153
drawsel
calc majdescript1 = 'Zone AE'
sel major1 = 440 and minor1 = 0154
drawsel
calc majdescript1 = 'Zone AO'
sel major1 = 440 and minor1 = 0155
drawsel
calc majdescript1 = 'Zone AO (Alluvial Fan)'
sel major1 = 440 and minor1 = 0156
drawsel
calc majdescript1 = 'Zone AH'
sel major1 = 440 and minor1 = 0157
drawsel
calc majdescript1 = 'Zone A99'
sel major1 = 440 and minor1 = 0158
drawsel
calc majdescript1 = 'Zone D'
sel major1 = 440 and minor1 = 0160
drawsel
calc majdescript1 = 'Zone X (500 Year)'
sel major1 = 440 and minor1 = 0161
drawsel
calc majdescript1 = 'Zone X'
```

```
sel major1 = 440 and minor1 = 0162
drawsel
calc majdescript1 = '1983 Undeveloped Coastal Barrier Area'
sel major1 = 440 and minor1 = 0163
drawsel
calc majdescript1 = '1990 Undeveloped Coastal Barrier Area'
sel major1 = 440 and minor1 = 0164
drawsel
calc majdescript1 = 'Otherwise Protected Area'
sel major1 = 440 and minor1 = 0170
drawsel
calc majdescript1 = '100-Year Flood Discharge Contained in Channel'
sel major1 = 440 and minor1 = 0171
drawsel
calc majdescript1 = '500-Year Flood Discharge Contained in Channel'
sel major1 = 440 and minor1 = 0172
drawsel
calc majdescript1 = 'Floodway Contained in Channel'
sel major1 = 440 and minor1 = 0180
drawsel
calc majdescript1 = 'Area Outside Study Limits'
sel major1 = 440 and minor1 = 0181
drawsel
calc majdescript1 = 'Area not Included'
sel major1 = 440 and minor1 = 0191
drawsel
calc majdescript1 = 'Area of Undesignated Flood Hazard'
sel major1 = 440 and minor1 = 0600
drawsel
calc majdescript1 = 'Multiple Source Data'
sel major1 = 440 and minor1 = 0164
drawsel
calc majdescript1 = 'Otherwise Protected Area'
sel major3 = 440 and minor3 = 0610
drawsel
calc majdescript3 = 'Feet'
sel major3 = 440 and minor3 = 0611
drawsel
calc majdescript3 = 'Meters'
sel major4 = 440 and minor4 = 0620
drawsel
calc majdescript4 = 'NGVD 29'
sel major4 = 440 and minor4 = 0621
drawsel
calc majdescript4 = 'NAVD 88'
sel major4 = 440 and minor4 = 0622
drawsel
calc majdescript4 = 'Other Vertical Datum'
```

```
sel major1 = 440 and minor1 = 0710
drawsel
calc majdescript1 = 'Floodway'
sel major1 = 440 and minor1 = 0712
drawsel
calc majdescript1 = 'Flow Easement'
sel major1 = 440 and minor1 = 0713
drawsel
calc majdescript1 = 'State Encroachment Area'
sel major2 = 441
drawsel
calc majdescript2 = 'Elevation'
sel major1 = 444
drawsel
calc majdescript1 = 'Decimal Fractions'
sel major2 = 445
drawsel
calc majdescript2 = 'Depth'
sel major2 = 447
drawsel
calc majdescript2 = 'Negative Elevation'
sel major1 = 449
drawsel
calc majdescript1 = 'Velocity in Whole Feet per Second'
save
q
build %line2% poly
&end
&sv line = [read %file% readstatus]
&end

&return
```

Appendix E. femahydro.aml

```
/********************************************************************************
/* Developed to add attributes to DFIRM DLGs on 1 December 1999 for Digital
/* Flood Insurance Rate Maps
/* femahydro.aml (HYDROGRAPHY DLG files)
/* DLG files must be in same directory as this AML to work correctly
/* 1 December 1999 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/********************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999
&type
&type This might take some time on slower systems!!!!!
&type

&if [exists hydro.txt -file] &then
&do
&type
&type File already exists.... deleting file hydro.txt
&type
[delete hydro.txt -file]
&end

[filelist *h*.dlg hydro.txt -file]

&sv file := [open hydro.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&sv temp1 = [substr %line% 1 5]
&sv temp2 = [substr %line% 6 3]
&sv line2 = %temp2%%temp1%
&type
&type Processing file %line%........
&type
dlgarc optional %line% %line2% %line2%pnt all
build %line2% line
build %line2% poly
build %line2%pnt point
&end
```

```
/*********************************************************
/* Hydrography Lines
/*********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
ef arc
de arc
draw
sel major1 = 430 and minor1 = 0250
drawsel
calc majdescript1 = 'Hydrography Bisector'
sel major1 = 430 and minor1 = 0260
drawsel
calc majdescript1 = 'Cross Section Shown on DFIRM'
sel major1 = 430 and minor1 = 0261
drawsel
calc majdescript1 = 'Computed Cross Section Not Shown on DFIRM'
sel major1 = 430 and minor1 = 0270
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, Firm is Source'
sel major1 = 430 and minor1 = 0271
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, USGS 100k DLG is Source'
sel major1 = 430 and minor1 = 0272
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, USGS 24k DLG is Source'
sel major1 = 430 and minor1 = 0273
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, Other Source'
sel major1 = 439 and minor1 = 0040
drawsel
calc majdescript1 = 'Coincidentce of Stream, Channel, or Shoreline with Zone Break'
sel major1 = 430 and minor1 = 0281
drawsel
calc majdescript1 = 'Profile Base Line'
```

```
sel major1 = 430 and minor1 = 0406
drawsel
calc majdescript1 = 'Dam or Weir'
sel major1 = 430 and minor1 = 0418
drawsel
calc majdescript1 = 'Culvert'
sel major1 = 430 and minor1 = 0435
drawsel
calc majdescript1 = 'Levee Crown/Floodwall'
sel major1 = 430 and minor1 = 0436
drawsel
calc majdescript1 = 'Road on Levee'
sel major1 = 430 and minor1 = 0466
drawsel
calc majdescript1 = 'Coastal Hard Point'
sel major2 = 433
drawsel
calc majdescript2 = 'Cross Section Alpha Character'
save
q
build %line2% line
&end
/*******************************************************
/* POINT
/*******************************************************
&if [exists %line2%pnt -point] &then
&do
&type
&type This sheet is %line2%pnt
&type
joinitem %line2%pnt.pat %line2%pnt.xcode %line2%pnt.pat %line2%pnt-id %line2%pnt-id
ae
mape %line2%pnt
ec %line2%pnt
ef point
de point
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
additem majdescript6 60 60 c
ef point
de point
draw
sel major1 = 430 and minor1 = 0350
drawsel
```

```
calc majdescript1 = 'Elevation Reference Mark (ERM)'
sel major1 = 430 and minor1 = 0351
drawsel
calc majdescript1 = 'River Mile/1000-Foot Marker'
sel major2 = 435
drawsel
calc majdescript2 = 'ERM Identifier'
sel major2 = 436
drawsel
calc majdescript2 = '1,000-Foot Marker Identifier'
sel major2 = 437
drawsel
calc majdescript2 = 'River Mile Marker Identifier'
sel major3 = 431
drawsel
calc majdescript3 = 'Elevation'
sel major4 = 432
drawsel
calc majdescript3 = 'Negative Elevation'
sel major4 = 434
drawsel
calc majdescript4 = 'Decimal Fraction'
sel major5 = 430 and minor5 = 0610
drawsel
calc majdescript5 = 'Feet'
sel major5 = 430 and minor5 = 0611
drawsel
calc majdescript5 = 'Meters'
sel major6 = 430 and minor6 = 0620
drawsel
calc majdescript6 = 'NGVD 29'
sel major6 = 430 and minor6 = 0621
drawsel
calc majdescript6 = 'NAVD 88'
sel major6 = 430 and minor6 = 0622
drawsel
calc majdescript6 = 'Other Vertical Datum'
save
q
build %line2%pnt point
&end
/********************************************************
/* POLY
/********************************************************
&if [exists %line2% -poly] &then
&do
&type
&type This sheet is %line2%
```

```
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
ef poly
de poly
draw
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
save
q
build %line2% poly
&end
&sv line = [read %file% readstatus]
&end
&return
```

Appendix F. femamappanel.aml

```
/**********************************************************************************
/* Developed to add attributes to DFIRM DLGs on 1 December 1999 for Digital
/* Flood Insurance Rate Maps
/* femamappanel.aml (MAP PANEL DLG files)
/* Modified 11 Jan. 2000 by James J. Damron
/* DLG files must be in same directory as this AML to work correctly
/* 1 December 1999 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/**********************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

&type This might take some time on slower systems!!!!!
&type

&if [exists mpanel.txt -file] &then
&do
&type
&type File already exists.... deleting file mpanel.txt
&type
[delete mpanel.txt -file]
&end

[filelist *m*.dlg mpanel.txt -file]

&sv file := [open mpanel.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&sv temp1 = [substr %line% 1 5]
&sv temp2 = [substr %line% 6 3]
&sv line2 = %temp2%%temp1%
&type
&type Processing file %line%........
&type
dlgarc optional %line% %line2% %line2%pnt all
build %line2% line
build %line2% poly
kill %line2%pnt all
```

```
&end
/***********************************************************
/* Map Panel Lines
/***********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
ef arc
de arc
draw
sel major1 = 420 and minor1 = 0250
drawsel
calc majdescript1 = 'FIRM Panel Neatline'
sel major2 = 420 and minor2 = 0250
drawsel
calc majdescript2 = 'FIRM Panel Neatline'
sel major1 = 420 and minor1 = 0270
drawsel
calc majdescript1 = 'Map Area Bisector'
sel major1 = 420 and minor1 = 0299
drawsel
calc majdescript1 = 'Processing Line'
save
q
build %line2% line
&end
/********************************************************
/* POLY
/********************************************************
&if [exists %line2% -poly] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id
ae
mape %line2%
```

```
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
sel major1 = 420 and minor1 = 0150
drawsel
calc majdescript1 = 'Community-Based FIRM Panel'
sel major1 = 420 and minor1 = 0151
drawsel
calc majdescript1 = 'Area Outside FIRM Panel Neatline'
sel major1 = 420 and minor1 = 0152
drawsel
calc majdescript1 = 'Community Based FIRM Panel Not Printed'
sel major1 = 420 and minor1 = 0153
drawsel
calc majdescript1 = 'Countywide FIRM Panel'
sel major1 = 420 and minor1 = 0154
drawsel
calc majdescript1 = 'Countywide FIRM Panel Not Printed'
sel major1 = 420 and minor1 = 0155
drawsel
calc majdescript1 = 'Unmapped Community'
sel major2 = 421
drawsel
calc majdescript2 = 'FIRM Panel Number'
sel major3 = 422
drawsel
calc majdescript3 = 'FIRM Panel Alpha Character'
sel major4 = 423
drawsel
calc majdescript4 = 'State FIPS Code'
sel major5 = 424
drawsel
calc majdescript5 = 'Community Number'
sel major5 = 425
drawsel
calc majdescript5 = 'Countywide Map Number'
save
q
build %line% poly
```

```
&end
&sv line = [read %file% readstatus]
&end

&return
```

Appendix G. femapolitical.aml

```
/*********************************************************************************
/* Developed to add attributes to DFIRM DLGs on 1 December 1999 for Digital
/* Flood Insurance Rate Maps
/* femapolitical.aml (POLITICAL DLG files)
/* DLG files must be in same directory as this AML to work correctly
/* 1 December 1999 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/*********************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

&type This might take some time on slower systems!!!!!
&type

&if [exists polit.txt -file] &then
&do
&type
&type File already exists.... deleting file polit.txt
&type
[delete polit.txt -file]
&end

[filelist *p*.dlg polit.txt -file]

&sv file := [open polit.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&type
&type This sheet is %line%
&type
&sv temp1 = [substr %line% 1 5]
&sv temp2 = [substr %line% 6 3]
&sv line2 = %temp2%%temp1%
&type
&type Processing file %line%
&type
dlgarc optional %line% %line2% %line2%pnt all
build %line2% line
```

```
build %line2% poly
kill %line2%pnt all
&end
/*********************************************************
/* Political Lines
/*********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
ef arc
de arc
draw
sel major1 = 410 and minor1 = 0200
drawsel
calc majdescript1 = 'Corporate Boundary'
sel major1 = 410 and minor1 = 0210
drawsel
calc majdescript1 = 'County Boundary'
sel major1 = 410 and minor1 = 0230
drawsel
calc majdescript1 = 'Area Not Included Boundary'
sel major1 = 410 and minor1 = 0240
drawsel
calc majdescript1 = 'Extraterritorial Jurisdictional Boundary'
sel major1 = 410 and minor1 = 0270
drawsel
calc majdescript1 = 'Community Bisector'
sel major1 = 410 and minor1 = 0299
drawsel
calc majdescript1 = 'Processing Line'
save
q
build %line2% line
&end
/******************************************************
/* POLY
/******************************************************
&if [exists %line2% -poly] &then
```

```
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id link
ae
mape %line2%
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
ef poly
de poly
draw
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
sel major1 = 410 and minor1 = 0101
drawsel
calc majdescript1 = 'Community Area'
sel major1 = 410 and minor1 = 0150
drawsel
calc majdescript1 = 'Undefined Political Area'
sel major2 = 410 and minor1 <> 0101 and minor <> 0150
drawsel
calc majdescript2 = 'State FIPS CODE'
sel major3 = 411
drawsel
calc majdescript3 = 'County FIPS Code'
sel major4 = 412
drawsel
calc majdescript4 = 'County Number'
save
q
build %line2% poly
&end
&sv line = [read %file% readstatus]
&end

&return
```

Appendix H. Readme for DFIRM e00 files

May 02, 2000

Virginia Beach, VA 51810 - DFIRM export files

These files were generated from 2x precision coverages.

File names are as follows:

vabch01e.e00 - Elevation Reference Marks tile01
vabch01f.e00 - Flood Polygon/Arc tile01
vabch01h.e00 - Hydrography Polygon/Arc tile01
vabch01m.e00 - Map Panels Polygon/Arc tile01
vabch01p.e00 - Political Areas Polygon/Arc tile01

Please note that Elevation Reference Marks are not applicable to all tiles.

These files represent tiles 1-12 for all other categories.

Master coverages are as follows :

vb_24k.e00 - USGS 24k quad tile grid
vb_erm.e00 - Elevation Reference Marks
vb_fall.e00 - Flood Polygon/Arc
vb_hall.e00 - Hydrography Polygon/Arc
vb_mall.e00 - Map Panels Polygon/Arc
vb_pall.e00 - Political Areas Polygon/Arc

These coverages are final as approved by Harvard Design & Mapping.

If there are any questions concerning the files, please contact:

Sue Hoegberg

Dewberry and Davis

8401 Arlington Blvd.

Fairfax, VA 22031-4666

(703) 849 - 0419

Appendix I. femaflde00.aml

```
/*****************************************************************************
/* Developed to add attributes to DFIRM E00 files for Digital
/* Flood Insurance Rate Maps (Modified AML from DFIRM DLG version)
/* Arc Interchange (e00) files
/* femaflde00.aml (FLOOD HAZARD ZONE files)
/* Modified May 2000 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/*****************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

&type
&type This might take some time on slower systems!!!!!
&type

&if [exists flood.txt -file] &then
&do
&type
&type File already exists.... deleting file flood.txt
&type
[delete flood.txt -file]
&end

[filelist *f*.e00 flood.txt -file]

/*&sv file := [open [getfile *.txt -file] ok -r]
&sv file := [open flood.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&sv temp1 = [substr %line% 1 8]
&sv line2 = %temp1%
&type
&type Processing file %line%........
&type
import auto %line2%.e00 %line2%
build %line2% line
build %line2% poly
/*clean %line2% %line2% 0.65 0.65 poly
```

```
/*build %line2%pnt point
&end
/***********************************************************
/* Lines
/***********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
/*joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
ef arc
de arc
draw
sel major1 = 440 and minor1 = 0204
drawsel
calc majdescript1 = 'Apparent Limit'
sel major1 = 440 and minor1 = 0245
drawsel
calc majdescript1 = '100-Year Floodplain Boundary'
sel major1 = 440 and minor1 = 0246
drawsel
calc majdescript1 = '500-Year Floodplain Boundary'
sel major1 = 440 and minor1 = 0247
drawsel
calc majdescript1 = 'Zone Break'
sel major1 = 440 and minor1 = 0248
drawsel
calc majdescript1 = 'Zone D'
sel major1 = 440 and minor1 = 0249
drawsel
calc majdescript1 = 'Floodway'
sel major1 = 440 and minor1 = 0250
drawsel
calc majdescript1 = 'Flow Easement'
sel major1 = 440 and minor1 = 0251
drawsel
```

```
calc majdescript1 = 'Limit of Detailed Study'
sel major1 = 440 and minor1 = 0252
drawsel
calc majdescript1 = 'Limit of Floodway'
sel major1 = 440 and minor1 = 0253
drawsel
calc majdescript1 = 'Limit of Study'
sel major1 = 440 and minor1 = 0254
drawsel
calc majdescript1 = 'State Encroachment Line'
sel major1 = 440 and minor1 = 0256
drawsel
calc majdescript1 = '1983 Undeveloped Coastal Barrier Area Boundary'
sel major1 = 440 and minor1 = 0257
drawsel
calc majdescript1 = '1990 Undeveloped Coastal Barrier Area Boundary'
sel major1 = 440 and minor1 = 0258
drawsel
calc majdescript1 = 'Otherwise Protected Area Boundary'
sel major1 = 440 and minor1 = 0261
drawsel
calc majdescript1 = 'Base Flood Elevation (BFE) Line'
sel major1 = 440 and minor1 = 0262
drawsel
calc majdescript1 = 'Interpolated Base Flood Elevation (BFE) Line'
sel major1 = 440 and minor1 = 0270
drawsel
calc majdescript1 = 'Zone Bisector'
sel major1 = 440 and minor1 = 0299
drawsel
calc majdescript1 = 'Processing Line'
sel major1 = 440 and minor1 = 0600
drawsel
calc majdescript1 = 'Multiple Source Data'
sel major3 = 440 and minor3 = 0610
drawsel
calc majdescript3 = 'Feet'
sel major3 = 440 and minor3 = 0611
drawsel
calc majdescript3 = 'Meters'
sel major4 = 440 and minor4 = 0620
drawsel
calc majdescript4 = 'NGVD 29'
sel major4 = 440 and minor4 = 0621
drawsel
calc majdescript4 = 'NAVD 88'
sel major4 = 440 and minor4 = 0622
drawsel
```

```
calc majdescript4 = 'Other Vertical Datum'
sel major1 = 440 and minor1 = 0710
drawsel
calc majdescript1 = 'Floodway'
sel major1 = 440 and minor1 = 0712
drawsel
calc majdescript1 = 'Flow Easement'
sel major1 = 440 and minor1 = 0713
drawsel
calc majdescript1 = 'State Encroachment Area'
sel major2 = 440 and minor2 = 0246
drawsel
calc majdescript2 = '500-Year Floodplain Boundary'
sel major2 = 440 and minor2 = 0249
drawsel
calc majdescript2 = 'Floodway'
sel major2 = 441
drawsel
calc majdescript2 = 'Elevation'
sel major3 = 440 and minor3 = 0246
drawsel
calc majdescript3 = '500-Year Floodplain Boundary'
sel major3 = 444
drawsel
calc majdescript3 = 'Decimal Fractions'
sel major2 = 445
drawsel
calc majdescript2 = 'Depth'
sel major2 = 447
drawsel
calc majdescript2 = 'Negative Elevation'
sel major5 = 449
drawsel
calc majdescript5 = 'Velocity in Whole Feet per Second'
save
q
build %line2% line
&end
/******************************************************
/* POLY
/******************************************************
&if [exists %line2% -poly] &then
&do
&type
&type This sheet is %line2%
&type
/*joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id
ae
```

```
mape %line2%
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
ef poly
de poly
draw
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
sel major1 = 440 and minor1 = 0150
drawsel
calc majdescript1 = 'Zone V'
sel major1 = 440 and minor1 = 0151
drawsel
calc majdescript1 = 'Zone VE'
sel major1 = 440 and minor1 = 0152
drawsel
calc majdescript1 = 'Zone A'
sel major1 = 440 and minor1 = 0153
drawsel
calc majdescript1 = 'Zone AE'
sel major1 = 440 and minor1 = 0154
drawsel
calc majdescript1 = 'Zone AO'
sel major1 = 440 and minor1 = 0155
drawsel
calc majdescript1 = 'Zone AO (Alluvial Fan)'
sel major1 = 440 and minor1 = 0156
drawsel
calc majdescript1 = 'Zone AH'
sel major1 = 440 and minor1 = 0157
drawsel
calc majdescript1 = 'Zone A99'
sel major1 = 440 and minor1 = 0158
drawsel
calc majdescript1 = 'Zone D'
sel major1 = 440 and minor1 = 0160
drawsel
calc majdescript1 = 'Zone X (500 Year)'
sel major1 = 440 and minor1 = 0161
drawsel
```

```
calc majdescript1 = 'Zone X'
sel major1 = 440 and minor1 = 0162
drawsel
calc majdescript1 = '1983 Undeveloped Coastal Barrier Area'
sel major1 = 440 and minor1 = 0163
drawsel
calc majdescript1 = '1990 Undeveloped Coastal Barrier Area'
sel major1 = 440 and minor1 = 0164
drawsel
calc majdescript1 = 'Otherwise Protected Area'
sel major1 = 440 and minor1 = 0170
drawsel
calc majdescript1 = '100-Year Flood Discharge Contained in Channel'
sel major1 = 440 and minor1 = 0171
drawsel
calc majdescript1 = '500-Year Flood Discharge Contained in Channel'
sel major1 = 440 and minor1 = 0172
drawsel
calc majdescript1 = 'Floodway Contained in Channel'
sel major1 = 440 and minor1 = 0180
drawsel
calc majdescript1 = 'Area Outside Study Limits'
sel major1 = 440 and minor1 = 0181
drawsel
calc majdescript1 = 'Area not Included'
sel major1 = 440 and minor1 = 0191
drawsel
calc majdescript1 = 'Area of Undesignated Flood Hazard'
sel major1 = 440 and minor1 = 0600
drawsel
calc majdescript1 = 'Multiple Source Data'
sel major1 = 440 and minor1 = 0164
drawsel
calc majdescript1 = 'Otherwise Protected Area'
sel major3 = 440 and minor3 = 0610
drawsel
calc majdescript3 = 'Feet'
sel major3 = 440 and minor3 = 0611
drawsel
calc majdescript3 = 'Meters'
sel major4 = 440 and minor4 = 0620
drawsel
calc majdescript4 = 'NGVD 29'
sel major4 = 440 and minor4 = 0621
drawsel
calc majdescript4 = 'NAVD 88'
sel major4 = 440 and minor4 = 0622
drawsel
```

```
calc majdescript4 = 'Other Vertical Datum'
sel major1 = 440 and minor1 = 0710
drawsel
calc majdescript1 = 'Floodway'
sel major1 = 440 and minor1 = 0712
drawsel
calc majdescript1 = 'Flow Easement'
sel major1 = 440 and minor1 = 0713
drawsel
calc majdescript1 = 'State Encroachment Area'
sel major2 = 441
drawsel
calc majdescript2 = 'Elevation'
sel major1 = 444
drawsel
calc majdescript1 = 'Decimal Fractions'
sel major2 = 445
drawsel
calc majdescript2 = 'Depth'
sel major2 = 447
drawsel
calc majdescript2 = 'Negative Elevation'
sel major1 = 449
drawsel
calc majdescript1 = 'Velocity in Whole Feet per Second'
save
q
build %line2% poly
&end
&sv line = [read %file% readstatus]
&end

&return
```

Appendix J. femahydroe00.aml

```
/*******************************************************************************
/* Developed to add attributes to DFIRM E00 files for Digital
/* Flood Insurance Rate Maps (Modified AML from DFIRM DLG version)
/* Arc Interchange (e00) files
/* femahydrography.aml (HYDROGRAPHY DLG files)
/* Modified May 2000 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/*******************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999
&type
&type This might take some time on slower systems!!!!!
&type

&if [exists floodhaz.txt -file] &then
&do
&type
&type File already exists.... deleting file floodhaz.txt
&type
[delete floodhaz.txt -file]
&end

[filelist *h*.e00 floodhaz.txt -file]

/*&sv file := [open [getfile *.txt -file] ok -r]
&sv file := [open floodhaz.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then

&if [exists %line% -cover] &then
&do
&sv temp1 = [substr %line% 1 8]
&sv line2 = %temp1%
&type
&type Processing file %line%........
&type
import auto %line2%.e00 %line2%
build %line2% line
build %line2% poly
```

```
&end
/**********************************************************
/* Hydrography Lines
/**********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
/*joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
ef arc
de arc
draw
sel major1 = 430 and minor1 = 0250
drawsel
calc majdescript1 = 'Hydrography Bisector'
sel major1 = 430 and minor1 = 0260
drawsel
calc majdescript1 = 'Cross Section Shown on DFIRM'
sel major1 = 430 and minor1 = 0261
drawsel
calc majdescript1 = 'Computed Cross Section Not Shown on DFIRM'
sel major1 = 430 and minor1 = 0270
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, Firm is Source'
sel major1 = 430 and minor1 = 0271
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, USGS 100k DLG is Source'
sel major1 = 430 and minor1 = 0272
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, USGS 24k DLG is Source'
sel major1 = 430 and minor1 = 0273
drawsel
calc majdescript1 = 'Stream, Channel, or Shoreline, Other Source'
sel major1 = 439 and minor1 = 0040
drawsel
calc majdescript1 = 'Coincidentce of Stream, Channel, or Shoreline with Zone Break'
sel major1 = 430 and minor1 = 0281
drawsel
```

```
calc majdescript1 = 'Profile Base Line'
sel major1 = 430 and minor1 = 0406
drawsel
calc majdescript1 = 'Dam or Weir'
sel major1 = 430 and minor1 = 0418
drawsel
calc majdescript1 = 'Culvert'
sel major1 = 430 and minor1 = 0435
drawsel
calc majdescript1 = 'Levee Crown/Floodwall'
sel major1 = 430 and minor1 = 0436
drawsel
calc majdescript1 = 'Road on Levee'
sel major1 = 430 and minor1 = 0466
drawsel
calc majdescript1 = 'Coastal Hard Point'
sel major2 = 433
drawsel
calc majdescript2 = 'Cross Section Alpha Character'
save
q
build %line2% line
&end
/*****************************************************
/* POLY
/*****************************************************
&if [exists %line2% -poly] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
ef poly
de poly
draw
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
save
q
build %line2% poly
```

```
&end
&sv line = [read %file% readstatus]
&end
&return
```

Appendix K. femamape00.aml

```
/***************************************************************************
/* Developed to add attributes to DFIRM E00 files for Digital
/* Flood Insurance Rate Maps (Modified AML from DFIRM DLG version)
/* Arc Interchange (e00) files
/* femamape00.aml (MAP PANEL files)
/* Modified May 2000 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/***************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

&type This might take some time on slower systems!!!!!
&type

&if [exists mpanel.txt -file] &then
&do
&type
&type File already exists.... deleting file mpanel.txt
&type
[delete mpanel.txt -file]
&end

[filelist *m*.e00 mpanel.txt -file]

/*&sv file := [open [getfile *.txt -file] ok -r]
&sv file := [open mpanel.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&sv temp1 = [substr %line% 1 8]
&sv line2 = %temp1%
&type
&type Processing file %line%........
&type
import auto %line2%.e00 %line2%
build %line2% line
build %line2% poly
&end
/*********************************************************
```

```
/* Map Panel Lines
/************************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
ef arc
de arc
draw
sel major1 = 420 and minor1 = 0250
drawsel
calc majdescript1 = 'FIRM Panel Neatline'
sel major2 = 420 and minor2 = 0250
drawsel
calc majdescript2 = 'FIRM Panel Neatline'
sel major1 = 420 and minor1 = 0270
drawsel
calc majdescript1 = 'Map Area Bisector'
sel major1 = 420 and minor1 = 0299
drawsel
calc majdescript1 = 'Processing Line'
save
q
build %line2% line
&end
/*********************************************************
/* POLY
/*********************************************************
&if [exists %line2% -poly] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef poly
```

```
de poly
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
sel major1 = 420 and minor1 = 0150
drawsel
calc majdescript1 = 'Community-Based FIRM Panel'
sel major1 = 420 and minor1 = 0151
drawsel
calc majdescript1 = 'Area Outside FIRM Panel Neatline'
sel major1 = 420 and minor1 = 0152
drawsel
calc majdescript1 = 'Community Based FIRM Panel Not Printed'
sel major1 = 420 and minor1 = 0153
drawsel
calc majdescript1 = 'Countywide FIRM Panel'
sel major1 = 420 and minor1 = 0154
drawsel
calc majdescript1 = 'Countywide FIRM Panel Not Printed'
sel major1 = 420 and minor1 = 0155
drawsel
calc majdescript1 = 'Unmapped Community'
sel major2 = 421
drawsel
calc majdescript2 = 'FIRM Panel Number'
sel major3 = 422
drawsel
calc majdescript3 = 'FIRM Panel Alpha Character'
sel major4 = 423
drawsel
calc majdescript4 = 'State FIPS Code'
sel major5 = 424
drawsel
calc majdescript5 = 'Community Number'
sel major5 = 425
drawsel
calc majdescript5 = 'Countywide Map Number'
save
q
build %line% poly
&end
&sv line = [read %file% readstatus]
```

&end

&return

Appendix L. femapolite00.aml

```
/*******************************************************************************
/* Developed to add attributes to DFIRM DLGs on 1 December 1999 for Digital
/* Flood Insurance Rate Maps (Modified AML from DFIRM DLG version)
/* Arc Interchange (e00) files
/* femapolite00.aml (POLITICAL files)
/* 1 December 1999 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/*******************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

&type This might take some time on slower systems!!!!!
&type

&if [exists polit.txt -file] &then
&do
&type
&type File already exists.... deleting file polit.txt
&type
[delete polit.txt -file]
&end

[filelist *p*.e00 polit.txt -file]

/*&sv file := [open [getfile *p*.txt -file] ok -r]
&sv file := [open polit.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0

&if [exists %line% -file] &then
&do
&type
&type This sheet is %line%
&type
&sv temp1 = [substr %line% 1 8]
&sv line2 = %temp1%
&type
&type Processing file %line%
&type
import auto %line2%.e00 %line2%
build %line2% line
```

```
build %line2% poly
&end
/**********************************************************
/* Political Lines
/**********************************************************
&if [exists %line2% -line] &then
&do
&type
&type This sheet is %line2%
&type
joinitem %line2%.aat %line2%.acode %line2%.aat %line2%-id %line2%-id
ae
mape %line2%
ec %line2%
ef arc
de arc
draw
additem majdescript1 60 60 c
ef arc
de arc
draw
sel major1 = 410 and minor1 = 0200
drawsel
calc majdescript1 = 'Corporate Boundary'
sel major1 = 410 and minor1 = 0210
drawsel
calc majdescript1 = 'County Boundary'
sel major1 = 410 and minor1 = 0230
drawsel
calc majdescript1 = 'Area Not Included Boundary'
sel major1 = 410 and minor1 = 0240
drawsel
calc majdescript1 = 'Extraterritorial Jurisdictional Boundary'
sel major1 = 410 and minor1 = 0270
drawsel
calc majdescript1 = 'Community Bisector'
sel major1 = 410 and minor1 = 0299
drawsel
calc majdescript1 = 'Processing Line'
save
q
build %line2% line
&end
/*******************************************************
/* POLY
/*******************************************************
&if [exists %line2% -poly] &then
&do
```

```
&type
&type This sheet is %line2%
&type
joinitem %line2%.pat %line2%.pcode %line2%.pat %line2%-id %line2%-id link
ae
mape %line2%
ec %line2%
ef poly
de poly
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
ef poly
de poly
draw
sel major1 = 000 and minor1 = 0000
drawsel
calc majdescript1 = 'Outside Area'
sel major1 = 410 and minor1 = 0101
drawsel
calc majdescript1 = 'Community Area'
sel major1 = 410 and minor1 = 0150
drawsel
calc majdescript1 = 'Undefined Political Area'
sel major2 = 410 and minor1 <> 0101 and minor <> 0150
drawsel
calc majdescript2 = 'State FIPS CODE'
sel major3 = 411
drawsel
calc majdescript3 = 'County FIPS Code'
sel major4 = 412
drawsel
calc majdescript4 = 'County Number'
save
q
build %line2% poly
&end
&sv line = [read %file% readstatus]
&end

&return
```

Appendix M. femaelevmrk.aml

```
/*********************************************************************************
/* Developed to add attributes to DFIRM Elevation Reference Marks for
/* Arc Interchange (e00) files for Digital Flood Insurance Rate Maps
/* May 2000
/* FEMAELEVMRK.AML ( Elevation Reference Mark )
/* Modified June 6, 2000 James J. Damron (703) 428-8168 jdamron@tec.army.mil
/* 7701 Telegraph Road  Topographic Engineering Center Alexandria, VA 22315
/*********************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999
&type
&type This might take some time on slower systems!!!!!
&type

&if [exists elevrfmrk.txt -file] &then
&do
&type
&type File already exists.... Deleting file elevrfmrk.txt
&type
[delete elevrfmrk.txt -file]
&end

[filelist *e*.e00 elevrfmrk.txt -file]

/*&sv file := [open [getfile *.txt -file] ok -r]
&sv file := [open elevrfmrk.txt openstat -read]
&sv line = [read %file% readstatus]
&sv line = [locase %line%]

&do &while %readstatus% = 0
&if [exists %line% -file] &then
&do
&sv temp1 = [substr %line% 1 8]
&sv line2 = %temp1%
&type %temp1%
&type %line%
&type
&type Processing file %line2%.e00.........
&type
import auto %line2%.e00 %line2%pnt
build %line2%pnt point
&end
/*****************************************************
```

```
/* POINT
/**************************************************************
&if [exists %line2%pnt -point] &then
&do
&type
&type This sheet is %line2%pnt
&type
/*joinitem %line2%pnt.pat %line2%pnt.xcode %line2%pnt.pat %line2%pnt-id %line2%pnt-id
ae
mape %line2%pnt
ec %line2%pnt
ef point
de point
draw
additem majdescript1 60 60 c
additem majdescript2 60 60 c
additem majdescript3 60 60 c
additem majdescript4 60 60 c
additem majdescript5 60 60 c
additem majdescript6 60 60 c
additem elev 16 16 n 4
ef point
de point
draw
sel major1 = 430 and minor1 = 0350
drawsel
calc majdescript1 = 'Elevation Reference Mark (ERM)'
sel major1 = 430 and minor1 = 0351
drawsel
calc majdescript1 = 'River Mile/1000-Foot Marker'
sel major2 = 435
drawsel
calc majdescript2 = 'ERM Identifier'
sel major2 = 436
drawsel
calc majdescript2 = '1,000-Foot Marker Identifier'
sel major2 = 437
drawsel
calc majdescript2 = 'River Mile Marker Identifier'
sel major3 = 431
drawsel
calc majdescript3 = 'Elevation'
sel major4 = 432
drawsel
calc majdescript3 = 'Negative Elevation'
sel major4 = 434
drawsel
calc majdescript4 = 'Decimal Fraction'
```

```
sel major5 = 430 and minor5 = 0610
drawsel
calc majdescript5 = 'Feet'
sel major5 = 430 and minor5 = 0611
drawsel
calc majdescript5 = 'Meters'
sel major6 = 430 and minor6 = 0620
drawsel
calc majdescript6 = 'NGVD 29'
sel major6 = 430 and minor6 = 0621
drawsel
calc majdescript6 = 'NAVD 88'
sel major6 = 430 and minor6 = 0622
drawsel
calc majdescript6 = 'Other Vertical Datum'
sel all
save
q
build %line2%pnt point
&sv line = [read %file% readstatus]
&end
&end
&return
```

Appendix N. ERMs in NAD 27 and NGVD 29 Coordinates

NAD27 x-coord	NAD27 y-coord	NGVD29
396841.72000	4086656.13000	18.5200
399240.07000	4086026.08000	9.9100
397046.64000	4085956.90000	9.8500
394274.38000	4085372.63000	12.7900
401254.55000	4085367.89000	6.3500
396968.84000	4084967.63000	9.7600
398796.47000	4084653.51000	11.8800
398594.20000	4083033.83000	20.2300
393376.25000	4082586.98000	20.7100
407986.72000	4081567.85000	23.7600
411602.51000	4081242.74000	11.4600
412335.21000	4081130.30000	8.0500
398916.68000	4080984.20000	26.4700
397085.20000	4080297.93000	17.5800
412788.77000	4079500.59000	13.8300
406534.93750	4079260.25000	16.6900
409689.65625	4078651.25000	11.7100
400255.37500	4077885.25000	15.9700
406668.59375	4077671.00000	18.8700
405741.25000	4077589.25000	18.8700
394523.48000	4077565.11000	15.3400
399119.76000	4075987.59000	10.8000
392323.96654	4074643.24039	18.0400
404741.68750	4072198.75000	14.2800
399584.74000	4071874.52000	11.0400
396639.77000	4070827.25000	9.8600
406826.34375	4070778.00000	10.9900
411577.57000	4070741.06000	6.2000
402606.87500	4070370.25000	13.9500
409388.71875	4069045.25000	17.0100
398041.01000	4068666.68000	10.5700
415053.05000	4068459.81000	7.5600

400496.09375	4068458.00000	11.4700
406174.03125	4067967.25000	8.3500
401042.37500	4067951.50000	11.5600
407701.34375	4067862.25000	7.1800
405143.26000	4067183.47000	15.8600
415650.96000	4066938.44000	12.0400
416084.73000	4065515.76000	10.5600
404210.34000	4064736.04000	9.8500
409120.55000	4064523.71000	19.4700
401744.29914	4064072.32589	2.4300
416597.79960	4063810.96260	10.3300
408799.30000	4063413.08000	12.9400
410847.42145	4063115.37484	5.1600
408528.45000	4061222.29000	15.8700
408609.18000	4059750.11000	14.2600
409575.44000	4059369.31000	6.1900

Appendix O. elevextract.aml

```
/*******************************************************************************
/* ELEVEXTRACT.AML  07/12/99
/* James J. Damron
/* U.S. Army Topographic Engineering Center
/* 7701 Telegraph Road
/* Alexandria, VA 22315-3864
/* jdamron@tec.army.mil
/*
/* Extracts elevation data using an x,y ascii text file for a stack or
/* single grid
/*
/* filename - ASCII text file created          writefile - output of elevation
/*
/* type - type grid used for extraction        name - name of the grid or stack
/*
/* file - opens x,y ASCII coordinate file      line - selects new line of x,y
/*
/*******************************************************************************
&severity &error &ignore
&severity &warning &ignore
display 9999
&term 9999

/* Setting up files and output file name
&sv filename = [ response 'Please enter file name to write to' elev.txt ]
&sv writefile = [open %filename% openstatus -write]
&type
&sv type = [ response 'Please enter type of grid: single or stack' stack ]
&type
&sv name = [ response 'Please enter name of the grid for extraction' grid ]
&type
/* Setting up environment
mape %name%
&sv file := [open [getfile *.txt -file] ok -r]
&sv line = [read %file% readstatus]
&sv count = 1

/* Examining file type and grid
&if %type% = single and [exists %name% -grid] &then
  /* Opening file for processing and output to ASCII
        &do &while %readstatus% eq 0
                &type %line%
                &type
                &sv elev = [ show cellvalue %name% %line% ]
                &if [write %writefile% %line%,%elev%] = 0 &then
```

```
                &type Writing file to %filename% ....
                &type
                &type this many finished %count%
                &type
                &sv count = %count% + 1
                &sv line = [read %file% readstatus]
        &end

/* Examining file type and grid
&if %type% = stack and [exists %name% -stack] &then
  /* Opening file for processing and output to ASCII
        &do &while %readstatus% eq 0
                &type %line%
                &type
                &sv elev = [ show cellvalue %name% %line% ]
                &if [write %writefile% %line%,%elev%] = 0 &then
                &type Writing file to %filename% ....
                &type
                &type this many finished %count%
                &type
                &sv count = %count% + 1
                &sv line = [read %file% readstatus]
        &end
&sv count = %count% - 1
&type
&type File %filename% closed and this many files processed %count%.....
&return
```

Appendix P. USGS Generated Points and vb_24k Results

Map Panels	USGS	Meters	Feet	Inches
1	7	0.111740	0.366614	4.399375
1	10	0.111740	0.366614	4.399375
1	14	0.111740	0.366614	4.399375
1	22	0.111740	0.366614	4.399375
3	7	0.111740	0.366614	4.399375
3	10	0.111740	0.366614	4.399375
3	14	0.111740	0.366614	4.399375
3	22	0.111740	0.366614	4.399375
4	5	0.121300	0.397978	4.775747
4	9	0.121300	0.397978	4.775747
4	21	0.121300	0.397978	4.775747
8	7	0.111900	0.367138	4.405668
8	10	0.111900	0.367138	4.405668
8	14	0.111900	0.367138	4.405668
8	22	0.111900	0.367138	4.405668
9	7	0.111740	0.366614	4.399375
9	10	0.111740	0.366614	4.399375
9	14	0.111740	0.366614	4.399375
9	22	0.111740	0.366614	4.399375
12	7	0.111740	0.366614	4.399375
12	10	0.111740	0.366614	4.399375
12	14	0.111740	0.366614	4.399375
12	22	0.111740	0.366614	4.399375
15	27	0.113930	0.373780	4.485368
15	29	0.113930	0.373780	4.485368
15	32	0.113930	0.373780	4.485368
15	41	0.113930	0.373780	4.485368
18	5	0.121300	0.397978	4.775747
18	9	0.121300	0.397978	4.775747
18	21	0.121300	0.397978	4.775747
22	16	0.123020	0.403601	4.843227
25	5	0.121300	0.397978	4.775747
25	9	0.121300	0.397978	4.775747
25	21	0.121300	0.397978	4.775747
28	27	0.113930	0.373780	4.485368
28	29	0.113930	0.373780	4.485368
28	32	0.113930	0.373780	4.485368
28	41	0.113930	0.373780	4.485368

33	27	0.113930	0.373780	4.485368
33	29	0.113930	0.373780	4.485368
33	32	0.113930	0.373780	4.485368
33	41	0.113930	0.373780	4.485368
39	27	0.113930	0.373780	4.485368
39	29	0.113930	0.373780	4.485368
39	32	0.113930	0.373780	4.485368
39	41	0.113930	0.373780	4.485368
51	48	0.105970	0.347685	4.172223
51	53	0.105970	0.347685	4.172223
	Mean	0.114270	0.374909	4.498916
	Min	0.105970	0.347685	4.172223
	Max	0.123020	0.403601	4.843227
	STD	0.004046	0.013274	0.159294